LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA14 | Newton Purcell to Brackley

Water resources assessment (WR-002-014)

Water resources

November 2013

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Department for Transport

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise four parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the Newton Purcell to Brackley area, CFA14,these are:

- a water resources assessment (i.e. this appendix);
- a flood risk assessment (Appendix WR-003-014); and
- a hydraulic modelling report for the River Great Ouse at Turweston (Volume 5: Appendix WR-004-005).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Study area

1.2.1 The study area for CFA14 covers approximately 12km of the Proposed Scheme in the council districts of Cherwell, Aylesbury Vale and South Northamptonshire, extending from the Buckinghamshire-Oxfordshire county boundary between Newton Purcell and Barley Fields in the south to a point approximately 2.4km north-east of the edge of Brackley.

1.2.2 The spatial scope of the assessment was based upon the identification of surface water and groundwater features within 1km of the centre line of the route, except where there is clearly no hydraulic connectivity. For surface water features in urban areas, the extent was reduced to 500m. Outside of these distances it is unlikely that direct impacts upon the water environment will be attributable to the Proposed Scheme. Where works extend more than 200m from the centre line, for example at stations and depots, professional judgement has been used in selecting the appropriate limit to the extension in spatial scope required. For the purposes of this assessment this spatial scope is defined as the study area.

1.2.3 The main environmental features of relevance to water resources within the study area include:

- the River Great Ouse, which is a main river, and associated drains and tributaries including the stream at Mixbury, the Radstone Brook and its tributaries, and tributaries of the Padbury Brook, which are ordinary watercourses;
- the Principal aquifers of the White Limestone Formation, the Blisworth Limestone Formation and the Taynton Limestone Formation;

- a number of Secondary A aquifers including the Cornbrash Formation, the Forest Marble Formation, the Horsehay Sand Formation and the Sharp's Hill Formation;
- the Rutland Formation Secondary B aquifer;
- an unlicensed groundwater abstraction at Mixbury Hall; and
- water dependent habitats: the Helmdon Disused Railway SSSI, the Turweston Manor Grassland LWS and Fox Covert (Whitfield) LWS.

1.2.4 Key environmental issues relating to water resources include:

- the potential impacts of culvert and viaduct crossings on the flow and quality of watercourses, including the River Great Ouse, tributaries of Padbury Brook, the stream at Mixbury and the Radstone Brook and its tributaries;
- the need for channel diversions and/or minor realignments on the River Great Ouse and other watercourses;
- the lowering of local groundwater levels due to drainage of shallow groundwater by cuttings, such as the Barton to Mixbury cutting, Turweston cutting, Mixbury cutting and Brackley south and north cuttings;
- the interception of groundwater flowing towards the Turweston Manor Grassland LWS;

1.2.5 Where a residual impact or mitigation for water resources has a consequent effect on ecology, this is discussed further in Volume 2, Newton Purcell to Brackley (CFA report 14), Section 7.

2 Stakeholder engagement

2.1.1 Discussions have been held with the following stakeholders to inform the water resources assessment:

- the Environment Agency;
- the Canal & River Trust (formerly British Waterways);
- Buckinghamshire County Council and Aylesbury Vale District Council (AVDC); and
- private licensees by way of a questionnaire and requesting further information or a meeting to more accurately assess and understand any potential risks to private abstractions.

3 Baseline data

3.1 General

3.1.1 The following sub-sections provide a current description of water resources within the study area including surface water and groundwater features.

3.1.2 All water bodies in this area fall within the Upper and Bedford Ouse sub-catchment of the Anglian River Basin District as defined under the Water Framework Directive[1] (WFD) and are covered by the River Basin Management Plan[2] (RBMP).

3.2 Surface water

3.2.1 All surface water features within 1km of the route are presented in Table 1.

3.2.2 The current surface water baseline and water features with codes listed in Table 1 are shown in Map WR-01-020 and Map WR-01-021 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The map reference is in one of two forms. If the feature has a specific reference number then this is provided (e.g. a surface water crossing will be referenced as SWC-CFA14-01). If the feature has no specific reference its location on a specific map is provided (e.g. WR-01-020, D6) where D6 is a grid reference using the map specific grid.

3.2.3 The surface water features are based on the Environment Agency's Detailed River Network (DRN) with the addition of water bodies noted on the Ordnance Survey's (OS) 'OS VectorMapDistrict'.

[1] European Parliament and European Council (2000). Water Framework Directive - Directive 200/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.
[2] Environment Agency (2009). River Basin Management Plan, Anglian River Basin District

Table 1: Surface water features within 1km of the route in the study area

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed tributary of Padbury Brook	Unnamed tributary will be crossed by the route north-east of Newton Purcell. (SWC-CFA14-01, SWC-CFA14-10 to SWC-CFA14-12).	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	0.0006	0.99	The tributary flows from the north, near Barleyfields Barn Farm parallel with the route, enters a culvert under Station House and the A4421 and joins another drain on the Calvert, Twyford and Chetwode area (CFA13) and CFA14 boundary. This eventually joins the Padbury Brook further south.
Unnamed pond south of Barley Fields	Field pond approximately 40m east of the route, south of Barley Fields. (CFA14-P01)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.
Culverted tributary of Padbury Brook	Unnamed tributary will be crossed by the route in culvert, north-east of Newton Purcell. (SWC-CFA14-02 and SWC-CFA14-13)	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	0.0005	0.93	The drain flows from the north, near Boundary Farm and enters a culvert under Station House and A4421. The drain joins the watercourse noted above near Station House and will be crossed by the route at SWC-CFA14-1. Eventually joins the Padbury Brook further south.

[3] Water-feature classifications: Section 113 of the Water Resources Act 1991 defines a main river as a watercourse that is shown as such on a main river map. Section 72 of the Land Drainage Act 1991 defines an ordinary watercourse as 'a watercourse that is not part of a main river'. Section 221 of the Water Resources Act 1991 defines a watercourse as including 'all rivers and streams, ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers) and passages through which water flows'. Main rivers are larger rivers and streams designated by the Department for Environment, Food and Rural Affairs (Defra) on the main river map and are regulated by the Environment Agency.

[4] For examples of receptor value see Table 43 in the Scope and Methodology Report (SMR) Addendum, Volume 5: Appendix CT-001-000/2.

[5] Q95 is the flow which is exceeded for 95% of the time (i.e. it is a low flow and the river will only have flows less than this for 5% of the time).

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed pond	Field pond approximately 280m west of the route, north of Newton Purcell. (CFA14-P02)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.
Two unnamed ponds	Approximately 140m east of the route, at Barley Fields. (CFA14-P03)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated ponds not connected to any other surface water feature.
Unnamed tributary of Padbury Brook	Unnamed tributary running south, approximately 850m west of the route, and west of Newton Purcell.	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	Not applicable	Not applicable	This watercourse eventually joins Padbury Brook further south.
Five unnamed ponds	Between Barleyfield Barn Farm to the west of the route and Boundary Farm to the east of the route. (SWC-CFA14-14 and CFA14-P04)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated ponds not connected to any other surface water feature. Approximately 50 - 420m from the route, one pond is on the route.
Five unnamed ponds and field drain	Between 300 – 540m west of the route, south of Diggings Wood. (CFA14-P05)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The field ponds and drain are not connected to any other surface water feature.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed pond	Field pond approximately 750m east of the route, north-east of Boundary Farm. (CFA14-P06)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.
Finmere Lakes	Includes four lake bodies within 60 – 550m east of the route surrounding Finmere Plantation. (CFA-P07)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	There are also approximately nine ponds and a field drain near the plantation.
Unnamed tributary of River Great Ouse	A drain approximately 850m east of the route south of Finmere.	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	Not applicable	Not applicable	The drain runs to the south of Finmere, through Tingewick (in culvert) and further east joins the River Great Ouse near Radclive.
Seven unnamed ponds	Seven field ponds surrounding Widmore Farm approximately 250m west of the route. (CFA14-P08)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated ponds not connected to any other surface water feature.
Unnamed pond	West of Finmere, approximately 910m east of the route. (CFA14-P09)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Six unnamed ponds	Near Warren Farm, approximately 240 - 700m east of the route. (CFA14-P10)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated ponds not connected to any other surface water feature.
Unnamed pond	Near Mixbury Lodge Farm, approximately 490m west of the route. (CFA14-P11)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.
Unnamed pond	To the east of Mixbury, approximately 410m west of the route. (CFA14-P12)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.
Unnamed pond	Near Hollow Barn, approximately 215m east of the route. (CFA14-P13)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.
Unnamed drain (stream at MIxbury)	This stream will be crossed by the route to the east of Mixbury. (SWC-CFA14-03)	Ordinary watercourse	Not applicable	Not applicable	Moderate	0.002	3.31	The brook starts to the west of Mixbury in two separate drains, which join at Mixbury and then flows east joining the River Great Ouse near Fulwell (approximately 900m east of the route).

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed pond	To the south of Westbury and adjacent to the drains and channel of the River Great Ouse, approximately 830m east of the route. (CFA14-P14)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Pond is on the floodplain of the River Great Ouse. Under high flood conditions it will be hydraulically connected to the river.
River Great Ouse	The River Great Ouse will be crossed by the route three times; to the west of Westbury and to the north of Turweston. (SWC-CFA14-04, SWC-CFA14-05 and SWC-CFA14-06).	Main river	Ouse (GB105033037860) Moderate Ouse (GB105033037880) Good	Good potential Good (by 2015)	High	0.05 (SWC-CFA14-04) 0.02 (SWC-CFA14-05 and SWC-CFA14-06)	76.77 38.0	The River Great Ouse, at this section of the catchment, is a small to medium sized watercourse flowing south-west from Whitfield to Brackley. To the north of Turweston the River Great Ouse splits into two channels for approximately 500m. When at Brackley, it then flows east towards Westbury and south to Fulwell before continuing eastwards towards Buckingham. In this area, it has been heavily modified with existing culverts to the east and west of the route. The river has two different WFD statuses in the course of CFA14. Its current status between Whitfield and Brackley is Good (SWC-CFA14-05 and SWC-CFA14-06) while between Brackley and Westbury (SWC-CFA14-04) it is Moderate.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed pond	To the west of Westbury, approximately 185m east of the route. (CFA14-P15)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond not connected to any other surface water feature.
Unnamed lake	Approximately 785m west of the route situated between the Brackley sewage works and the River Great Ouse. (CFA14-P16)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated lake not connected to any other surface water feature.
Unnamed drain and pond	Unnamed drain running south from Oatleys Farm, approximately 350m east of the route. Unnamed pond located south of Oatleys Farm.	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	Not applicable	Not applicable	Unnamed drain flows towards Westbury where it joins the River Great Ouse.
Two unnamed ponds and drain	To the south of Turweston, approximately 280 - 380m west of the route. (CFA14-P17)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated ponds and drain not connected to any other surface water feature.
Two unnamed ponds	Near Oatleys Wood, approximately 300 east of the route. (CFA14-P18)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated ponds not connected to any other surface water feature.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Two unnamed ponds	North of Turweston, approximately 170 – 390m west of the route. (CFA14-P19)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated ponds not connected to any other surface water feature.
Two unnamed drains and two unnamed ponds	Two unnamed drains approximately 200-250m east of the route, to the north of Turweston, running south-east into the River Great Ouse. (CFA14-P20)	Ordinary watercourse	No status class shown in RBMP– assumed status Good	No status class shown in RBMP– assumed status Good	Moderate	Not applicable	Not applicable	There are also two ponds adjacent to the small drains.
Unnamed tributary of River Great Ouse	Drain running south from near Hall Farm, 450 to 900m west of the route. (SWC-CFA14-15)	Ordinary watercourse	No status class shown in RBMP– assumed status Good	No status class shown in RBMP– assumed status Good	Moderate	0.001	2.18	Unnamed drain joins the Great River Ouse between Brackley and Turweston.
Radstone Brook	Radstone Brook flows from the west to east, and will be crossed by the route south of Radstone. (SWC-CFA14-07 and SWC-CFA14-16 to SWC-CFA14-18)	Ordinary watercourse	Radstone Brook (GB105033037940) Moderate	Good potential	High	0.0006	0.98	The Radstone Brook is a small watercourse which has been heavily modified in the area. It continues to flow to the east and then joins the River Great Ouse, to the west of Biddlesden.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed tributary of the Radstone Brook	Flowing south from Radstone, approximately 360m east of the route.	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	Not applicable	Not applicable	Small unnamed tributary flowing south from Radstone, approximately 360m east of the route, where it enters the Radstone Brook.
Unnamed tributary of the Radstone Brook	Flowing in a culvert west of Radstone, approximately 500m west of the route.	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	Not applicable	Not applicable	Small unnamed tributary flowing in a culvert west of Radstone, approximately 500m west of the route, where it enters the Radstone Brook.
Unnamed tributary of the Radstone Brook	Flows from the west to east, and will be crossed by the route north-west of Radstone. (SWC-CFA14-08 and SWC-CFA14-19)	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	0.0003	0.52	The tributary joins the Radstone Brook approximately 850m east of the route, to the north of Radstone. Here, the Radstone Brook has a Moderate status.
Unnamed pond	To the north of Radstone, approximately 950m east of the route. (CFA14-P21)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is adjacent to the Radstone Brook.
Headwater channel of the Radstone Brook	Will be crossed by the route on the CFA14/Greatworth to Lower Boddington area (CFA15) boundary, south of Halse Copse. (SWC-CFA14-09)	Ordinary watercourse	No status class shown in RBMP– assumed status Moderate	No status class shown in RBMP– assumed status Good potential	Moderate	0.0003	0.51	The channel joins another drain running south-east approximately 650m east of the route. The Radstone Brook continues to flow in a general south-east direction thereafter.

3.2.4 There are no surface water abstractions identified within 1km of the route in the study area[6]. There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

3.2.5 Table 2 summarises surface water discharge consents within 1km of the route.

Table 2: Surface water discharge consents in the study area

Reference number	Permit identifier	Distance (and direction) from route (m)	Discharge type	Receiving water body
CFA14WD2	PRCNF04069	494m (west)	Discharge of other matter – surface water	Tributary of River Great Ouse
CFA14WD3 CFA14WD49	PR1NF1298	399m (west)	Sewage discharge – final/treated effluent	River Great Ouse
CFA14WD4 CFA14WD29	PRCNF04068	494m (west)	Sewage discharge – final/treated effluent	Tributary of River Great Ouse
CFA14WD6 CFA14WD46	AWCNF11059	668m (west)	Sewage discharge – pumping station Public sewage – storm sewage overflow	Turweston Brook / River Great Ouse
CFA14WD8	AW1NF1464	272m (east)	Sewage discharge – final/treated effluent	Tributary of River Great Ouse
CFA14WD9	AWCNF20	761m (east)	Sewage discharge – final/treated effluent	River Great Ouse
CFA14WD15 CFA14WD70 CFA14WD71 CFA14WD72 CFA14WD83 CFA14WD84	AW1NF578	893m (east)	Sewage discharge – final/treated effluent Sewage discharge – storm overflow/storm tank	River Great Ouse
CFA14WD33 CFA14WD45	AW1NFG1156	673m (west)	Agricultural effluents	River Great Ouse
CFA14WD34	AW1NF405A	761m (east)	Unknown	River Great Ouse
CFA14WD37	PR1NFG0923	736m (east)	Agricultural effluents	Unknown tributary
CFA14WD50 CFA14WD56	PRCNF14334	12m (west) 794m (west)	Sewage discharge – final/treated effluent	Ditch tributary of River Great Ouse
CFA14WD64 CFA14WD65	AWCNF1024	826m (west)	Sewage discharge – final/treated effluent	River Great Ouse

[6] Surface water abstractions for public supply are not included.

Reference number	Permit identifier	Distance (and direction) from route (m)	Discharge type	Receiving water body
			Sewage discharge – storm overflow/storm tank	
CFA14WD68	PRCNF14708	663m (west)	Sewage and trade combined – unspecified	Tributary of River Great Ouse
CFA14WD69	PRCNF14758	662m (west)	Trade discharge – site drainage (contaminated surface water)	Tributary of River Great Ouse
CFA14WD76	PRCNF17570	192m (west)	Sewage discharge – final/treated effluent	Unnamed drain
CFA14WD77	PRCNF17571	211m (west)	Sewage discharge – final/treated effluent	Unnamed drain
CFA14WD87 CFA14WD88 CFA14WD89 CFA14WD90 CFA14WD91	NPSWQD008711	404m (east)	Sewage discharge – final/treated effluent	Tributary of Great River Ouse

3.3 Groundwater

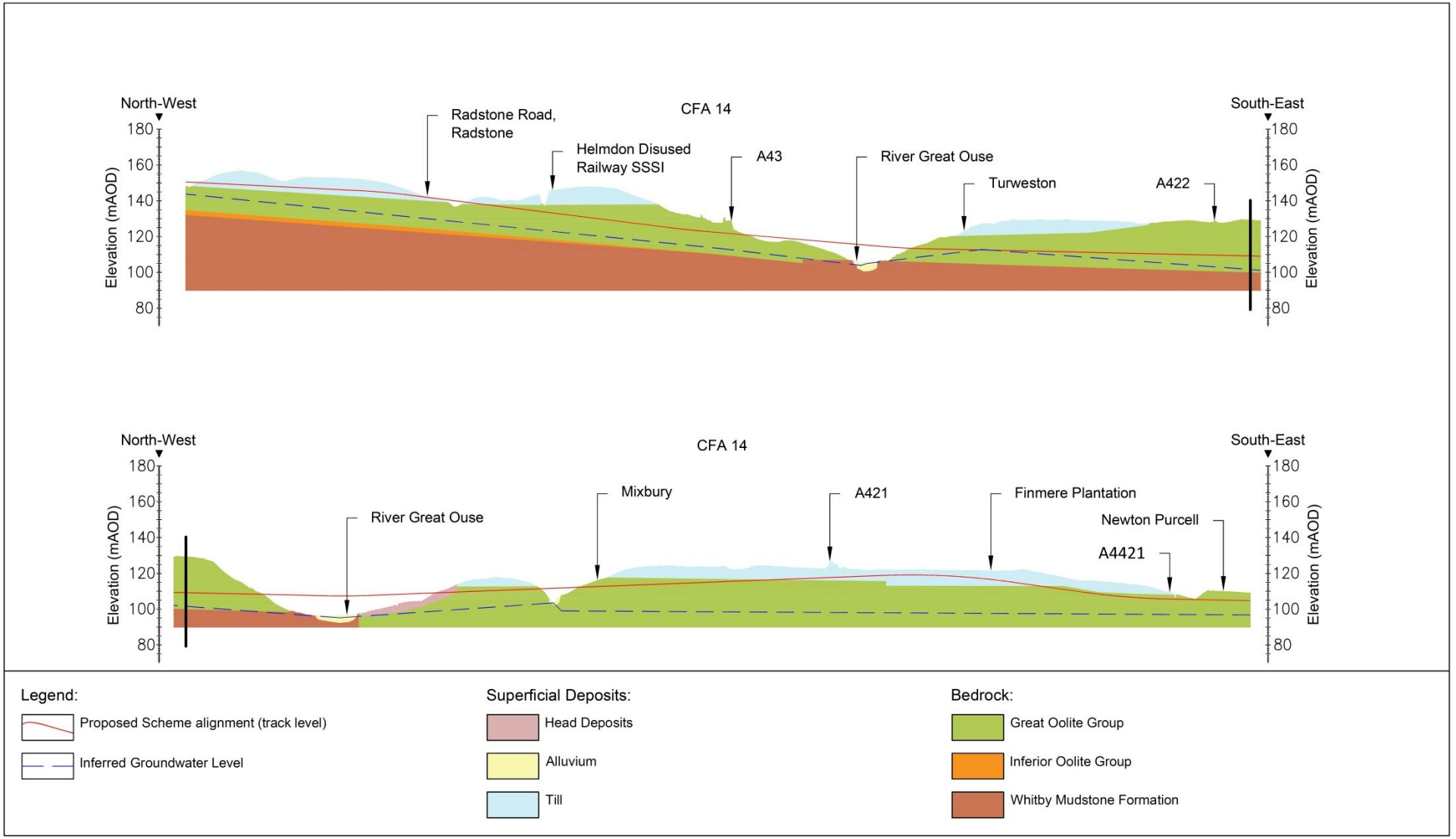
3.3.1 A summary of the geological units present in CFA14, along with their hydrogeological characteristics, is presented in the Land Quality section in Volume 2, CFA Report 14, Section 8.

3.3.2 Map WR-02-014 (Volume 5, Water Resources and Flood Risk Assessment Map Book) illustrates the spatial distribution of the uppermost superficial and bedrock formations within the study area. A schematic cross-section along the line of the route within this study area with regard to geological strata, maximum groundwater levels (where known) and the route of the Proposed Scheme is presented in Figure 1.

3.3.3 Superficial deposits in the study area comprise Alluvium, Head and Glaciofluvial deposits in the valleys, where they are likely to be in hydraulic continuity with local watercourses. Outside of the valleys, the superficial deposits are composed of Till which will contain very little groundwater.

3.3.4 Most of the route in this area traverses the Great Oolite Group, which largely comprises various limestone formations. The different formations within the Great Oolite Group are classified as Principal or Secondary aquifers. In the valley of the River Great Ouse, the Great Oolite formations are eroded to expose the underlying Whitby Mudstone Formation of the Lias Group, which is classified as unproductive strata and not considered a groundwater receptor.

Figure 1: Schematic cross section of geology and route in CFA14.



3.3.5 There are no public or private licensed abstractions within 1km of the route. No SPZ are traversed.

3.3.6 A single private unlicensed groundwater abstraction has been identified at Mixbury Hall, as illustrated in Map WR-02-014, F6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

3.3.7 There are no groundwater discharge consents within 1km of the route.

3.4 Surface water/groundwater interaction

3.4.1 Table 3 summarises surface water/groundwater interactions within 1km of the route.

Table 3: Surface water/groundwater interaction in the study area

Location description	Distance (m) and direction from route	Formation	Approximate elevation (metres above ordnance datum, m AOD)	Comments
A minor watercourse rises to the north-west of Westbury and to the east of Turweston. (Map WR-02-014, D5)	350m (north-east)	White Limestone Formation	105 - 120	The Turweston cutting will be at an elevation of approximately 110m AOD where it will pass this minor watercourse. Consequently it is possible that there will be a reduction in groundwater flow to this watercourse.
Several minor springs and issues rise to the south-west of Turweston. (Map WR-02-014, D6)	840m (south-west)	White Limestone Formation and Taynton Limestone Formation	105 - 110	These springs feed small areas of water dependent habitat. The Turweston cutting will be at an elevation of approximately 110m AOD where it will pass these springs and issues. Consequently it is possible that there could be a reduction in groundwater flow to these springs and issues.
Groundwater seepages have been identified within the Turweston Manor Grassland LWS, north of Turweston. (Map WR-02-014, D5)	100m (west)	White Limestone Formation and Taynton Limestone Formation	105 - 110	It is likely that groundwater seepage supports the damp grassland habitat at the Turweston Manor Grassland LWS.
A small stream rises to the south-west of Radstone and flows into a tributary of the River Great Ouse (Map WR-02-014, D6)	Will be crossed by route	Blisworth Limestone Formation, Taynton Limestone Formation and Horsehay Sand Formation	130 - 150	The source of this watercourse is on Glacial Till, however it is likely that it receives groundwater flow from the underlying limestones and sandstones as it passes into the valleys.
A small stream rises to the north-west of Radstone and flows eastward into a tributary of the River Great Ouse.	Will be crossed by route	Blisworth Limestone Formation, Taynton Limestone Formation and	135 - 150	The source of this watercourse is on Glacial Till, however it is likely that it receives groundwater flow from the underlying limestones and sandstones as it passes into the valleys.

Location description	Distance (m) and direction from route	Formation	Approximate elevation (metres above ordnance datum, m AOD)	Comments
(Map WR-02-014, D6)		Horsehay Sand Formation		

3.5 Water dependent habitats

3.5.1 Table 4 summarises the water dependent habitats within 1km of the route.

3.5.2 The table identifies where a water dependency exists. The assessment of the impact on water dependent ecology receptors is found in Volume 2, CFA Report 14, Section 7.

Table 4: Description of water dependent habitats in the study area

Name / location[7]	Distance (m) and direction from route	Designation	Comments
Turweston Manor Grassland (Map EC-01-034, F6)	Will be crossed by the Proposed Scheme	LWS	An area of damp grassland supported by groundwater seepage.
Helmdon Disused Railway (Map EC-01-035a, H6)	Will be crossed by the Proposed Scheme	SSSI	The SSSI is designated for Calcicolous Grassland.
Fox Covert (Whitfield) (Map EC-01-034, B7)	Small corner will be crossed by the Proposed Scheme	LWS	Three areas of lowland deciduous woodland, a habitat of principal importance and a local biodiversity action plan (BAP) habitat.

[7] Map references to Volume 5: Ecology map book

4 Site specific assessments

4.1 Surface water

4.1.1 Table 5 summarises all potential impacts and effects, both significant and not significant, to surface water features from the Proposed Scheme within the study area. Only those impacts and effects that are classed as significant are presented in Volume 2, CFA Report 14, Section 13.4.

4.1.2 Table 5 only includes water features which could potentially be affected by the Proposed Scheme. Features such as isolated ponds and drains which will lie outside the construction footprint and area of impact of the Proposed Scheme, are not included. Details of the features are, however, provided in Table 1.

4.1.3 The draft Code of Construction Practice (CoCP), referred to in Table 5, sets out the measures and standards of work that will be applied to the construction of the Proposed Scheme (see Volume 5: Appendix CT-003-000/1). These will provide effective management and control of the impacts during the construction period.

Table 5: Summary of potential impacts to surface water features

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Water features									
Unnamed tributary (drain) of Padbury Brook SWC-CFA14-01 SWC-CFA14-10 SWC-CFA14-11 SWC-CFA13-13	Moderate	Barton to Mixbury cutting Three culverts Earthworks - stockpile Channel diversion Highway construction	A diversion is required and a culvert (approximately 40m long) will be constructed about 30m north of the unnamed tributary (SWC-CFA-01). Surface water flow will be diverted into the drain from both the north and south on both sides of the route. During works for the culverts and diversions on the drain and the balancing pond and drainage, there is a potential for temporary impacts to flow. Potential sediment mobilisation or spills during construction.	Moderate impact Moderate effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report) The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Unnamed tributary (drain) of Padbury Brook SWC-CFA14-01	Moderate	Balancing pond and associated drainage	Permanent impact on flow regime in receiving watercourse. Deterioration in water quality from routine discharges from the railway and associated infrastructure or spills.	Negligible impact Neutral effect (Not significant)	Balancing pond before outfall to watercourse to restrict runoff rates and limit effect on water quality.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)
Culverted tributary (drain) of Padbury Brook SWC-CFA14-02 SWC-CFA14-12	Moderate	Barton to Mixbury cutting Existing culvert Channel diversion Highway construction	The drain flows from the north, near Boundary Farm and enters a culvert under Station House and the A4421. The drain joins the watercourse noted above near Station House and will be crossed by the route at SWC-CFA14-01. The design will utilise the existing culvert underneath the route and highway construction to the east.	Moderate impact Moderate effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Culverted tributary (drain) of Padbury Brook SWC-CFA14-02 SWC-CFA14-12	Moderate	Balancing pond and associated drainage	During works for the culverting of the drain, there is a potential for temporary effects during construction, for example, a short-term increase in sediment loading and temporary impacts to flow.	Negligible impact Neutral effect (Not significant)	Balancing pond before outfall to watercourse to restrict runoff rates and limit effect on water quality.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Five unnamed ponds near Barleyfield Barn/Boundary Farm SWC-CFA14-14	Low	Barton to Mixbury cutting	Two of the ponds adjacent to the track will be lost to construction and cuttings. The three ponds nearer Boundary Farm will not be impacted by construction of the route. No impact in terms of water resources.	Moderate impact Slight effect (Not significant)	Replacement of lost pond volume area within catchment by way of balancing ponds.	Negligible impact Neutral effect (Not significant)	None	Neutral	Construction (permanent)
Unnamed drain (stream at MIxbury) SWC-CFA14-03	Moderate	Mixbury embankment Culvert	During works for the culverting of the watercourse, there is a potential for temporary effects during construction, for example, a short-term increase in sediment loading and temporary impacts to flow.	Moderate impact Moderate effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Unnamed drain (stream at MIxbury) SWC-CFA14-03	Moderate	Balancing pond and associated drainage	Permanent impact on flow regime in receiving watercourse. Deterioration in water quality from routine discharges from the railway and associated infrastructure or spills.	Negligible impact Neutral effect (Not significant)	Balancing pond before outfall to watercourse to restrict runoff rates and limit effect on water quality.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)
River Great Ouse SWC-CFA14-04	High	Westbury viaduct Five balancing ponds with associated drainage	See Section 4.2 of this report. During the installation of seven pier footings, two of which will be constructed either side of the channel (approximately 15-20m away) and construction of the balancing ponds and drainage there could be a temporary increase in sediment in the watercourse.	Minor impact Moderate effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Neutral	Construction (temporary)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
River Great Ouse SWC-CFA14-05 and SWC-CFA14-06	High	Turweston viaduct Channel diversion Three balancing ponds with associated drainage	See Section 4.2 of this report. During diversion works and construction of pier footings and balancing ponds and drainage, there is potential for temporary effects related to construction, for example, a short-term increase in sediment loading and temporary impacts to flow.	Moderate impact Large effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Unnamed tributary of River Great Ouse near Foxhill Spinney SWC-CFA14-15	Moderate	New road realignment of the A43 and overbridge (foundations) Existing culvert Culvert	The majority of the drain will remain in the existing culvert to the north-east of Brackley, while a new culvert will be constructed for foundations associated with the new road/overbridge realignment leading to Whitfield. During works for the culverting of the watercourse, there is a potential for temporary effects during construction; for example, a short-term increase in sediment loading on watercourses and impacts to flow.	Moderate impact Moderate effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary and permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Radstone Brook SWC-CFA14-07 SWC-CFA14-16 SWC-CFA14-17 SWC-CFA14-18	High	Four new culverts Brackley embankment	During works for the culverting of the watercourse and construction of the balancing ponds and drainage, there is a potential for temporary effects during construction; for example, a short-term increase in sediment loading and impacts to flow.	Moderate impact Moderate effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Radstone Brook SWC-CFA14-07 SWC-CFA14-16 SWC-CFA14-17 SWC-CFA14-18	High	Three balancing ponds with associated drainage	Permanent impact on flow regime in receiving watercourse. Deterioration in water quality from routine discharges from the railway and associated infrastructure or spills.	Negligible impact Neutral effect (Not significant)	Balancing pond before outfall to watercourse to restrict runoff rates and limit effect on water quality.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Unnamed tributary (drain) of the Radstone Brook SWC-CFA14-08 SWC-CFA14-19	Moderate	Brackley north cutting Channel diversion Earthworks - stockpile	There is a ditch/field drain running north-east starting with a small issue near SWC-CFA14-19. The design will divert the ditch approximately 640m southwards where it will run parallel with the route before entering the Radstone Brook, south of Radstone. Approximately 230m of the former ditch, including the issue, will be lost. During diversion works for the channel, there will be the potential for temporary effects related to construction, for example, a short-term increase in sediment loading and temporary impacts to flow. The diverted water would enter the Radstone Brook further downstream than present. See Section 5.2 of this report.	Negligible impact Neutral effect (Not significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring. No practicable measures to replace the lost 230m of ditch.	Minor impact Slight effect (Not significant)	None	Minor impact Slight effect (Not significant)	Construction (temporary and permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Headwater channel of the Radstone Brook SWC-CFA14-09	Moderate	Culvert Greatworth south embankment Channel diversion	During works for the culverting of the watercourse and construction of the balancing ponds and drainage, there is a potential for temporary effects during construction, for example, a short-term increase in sediment loading and temporary impacts to flow.	Moderate impact Moderate effect (Significant)	Measures to be adopted in the design process (see Section 4.2 of this report). The mitigation measures set out within the draft CoCP to control sediment mobilisation and risk of spills. Pre- and post-construction monitoring.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Headwater channel of the Radstone Brook SWC-CFA14-09	Moderate	Two balancing ponds with associated drainage	Permanent impact on flow regime in receiving watercourse. Deterioration in water quality from routine discharges from the railway and associated infrastructure or spills.	Negligible impact Neutral effect (Not significant)	Balancing pond before outfall to watercourse to restrict runoff rates and limit effect on water quality.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)

4.2 Detailed assessments

Assessment of potential impacts of surface water crossings

4.2.1 The locations and descriptions of the surface water crossing in the study area are given in Table 6 and shown in Maps WR-01-020 and WR-01-021 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

4.2.2 The crossings listed in Table 6 are locations where temporary or permanent impacts from construction cannot be avoided. The approach will be to minimise the impact on ecology, water quality, flow and drainage. The impacts on ecology receptors are addressed in Volume 2, CFA Report 14, Section 7.

Table 6: Summary of watercourse crossings

Water feature	Crossing	Description	Length[1](m)	WFD water body, designation and current status
Unnamed tributary of Padbury Brook	SWC-CFA14-01	New culvert	40	No status class shown in RBMP– assumed status Moderate
Culverted tributary of Padbury Brook	SWC-CFA14-02	Existing culvert	188	No status class shown in RBMP– assumed status Moderate
Unnamed drain (stream at MIxbury)	SWC-CFA14-03	New culvert	40	No status class shown in RBMP– assumed status Moderate
River Great Ouse	SWC-CFA14-04	Westbury viaduct	300	River Great Ouse Moderate
River Great Ouse	SWC-CFA14-05	Turweston viaduct	80	River Great Ouse Good
River Great Ouse	SWC-CFA14-06	Turweston viaduct	80	River Great Ouse Good
Radstone Brook	SWC-CFA14-07	New culvert	34	Radstone Brook Moderate
Unnamed tributary of the Radstone Brook	SWC-CFA14-08	Diversion	Not applicable	No status class shown in RBMP– assumed status Moderate
Headwater channel of the Radstone Brook	SWC-CFA14-09	New culvert	30	No status class shown in RBMP– assumed status Moderate

Water feature	Crossing	Description	Length[1](m)	WFD water body, designation and current status
Unnamed tributary of Padbury Brook	SWC-CFA14-10	Stockpile	Not applicable	No status class shown in RBMP– assumed status Moderate
Unnamed tributary of Padbury Brook	SWC-CFA14-11	Drain diversion	Not applicable	No status class shown in RBMP– assumed status Moderate
Culverted tributary of Padbury Brook	SWC-CFA14-12	New culvert	30	No status class shown in RBMP– assumed status Moderate
Unnamed tributary of Padbury Brook	SWC-CFA14-13	New culvert	64	Not assessed by the Environment Agency
Unnamed ponds near Barleyfield Barn/Boundary Farm	SWC-CFA14-14	Pond will be lost to the Barton to Mixbury cutting	Not applicable	Not applicable
Unnamed tributary of River Great Ouse near Foxhill Spinney	SWC-CFA14-15	New culvert	68	No status class shown in RBMP– assumed status Good
Radstone Brook	SWC-CFA14-16	New culvert	7	No status class shown in RBMP– assumed status Moderate
Radstone Brook	SWC-CFA14-17	New culvert	36	No status class shown in RBMP– assumed status Moderate
Radstone Brook	SWC-CFA14-18	New culvert	60	No status class shown in RBMP– assumed status Moderate
Unnamed tributary of the Radstone Brook	SWC-CFA14-19	Diversion	Not applicable	No status class shown in RBMP– assumed status Moderate

[1] The length is based on the construction boundary. The actual length of the culvert is to be confirmed.

4.2.3 The two viaducts (Turweston viaduct at SWC-CFA14-04, SWC-CFA14-05 and Westbury viaduct at SWC-CFA14-06, Map WR-01-021) and the drain diversion at SWC-CFA14-08 and SWC-CFA14-19 (Map WR-01-021) are addressed separately in following sub-sections because of their particular features.

4.2.4 The Radstone Brook crossings (SWC-CFA14-16 to SWC-CFA14-18, Map WR-01-021) are also addressed separately as it will involve multiple culverts and has been flagged as a potential WFD risk in the WFD Compliance Assessment (contained within the route-side Water Resources Appendix, Volume 5: Appendix WR-001-000).

4.2.5 The remainder of this sub-section assesses the impacts for all other crossings.

4.2.6 Design mitigation will be used to address the potential impacts of culvert crossings. The Environment Agency will be consulted on the design of the culverts and diversion proposals and any other mitigation measures. Mitigation measures will include:

- avoiding culverts where possible and maintaining an open watercourse;
- minimising culvert lengths as far as possible, even if this requires some realignment of the upstream approach reach;
- maintaining the natural bed profile within the channel, both in terms of channel gradients and substrates;
- maintaining natural flow depths, widths and velocities, (including natural variance and diversity) at the culvert inlet and outlet;
- constructing diversions and realigning channel sections in advance to allow stabilisation and vegetation growth, to minimise sediment mobilisation when the flow is first diverted; and
- other measures, to be agreed with the Environment Agency, to ensure that the culverts are environmentally sympathetic to minimise their impacts on natural processes and biodiversity as far as possible.

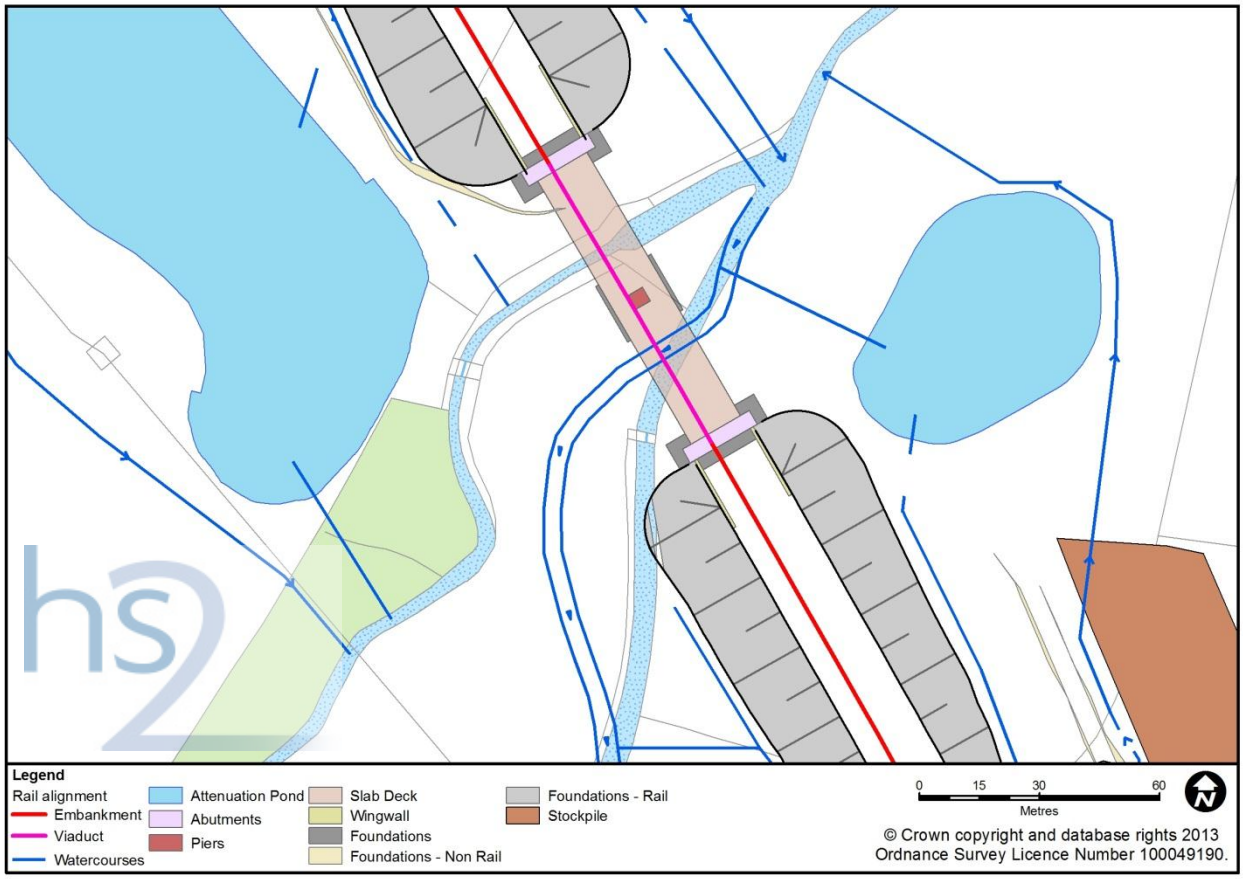
4.2.7 Construction of crossings will follow best practice as set out in the draft CoCP. These measures will reduce potential adverse impacts to negligible impacts.

Potential impacts of the Turweston viaduct on the River Great Ouse

4.2.8 The route will cross the River Great Ouse twice at SWC-CFA14-05 and SWC-CFA14-06 north of Turweston (Figure 2). The crossing locations are within the WFD water body Ouse (GB105033037880), which is currently at good ecological status.

4.2.9 The River Great Ouse has a catchment size of approximately 38km^2 at the downstream intersection with the Proposed Scheme, which is 1% of the total catchment area. There is an existing flow restriction approximately 1km downstream from the crossing, caused by the embankments and underbridges of the disused Great Central Main Line.

Figure 2: Proposed viaduct location north of Turweston



4.2.10 The Turweston viaduct will not constrict flow and the one proposed pier footing will be located outside of the main channels.

4.2.11 The mill race channel (SWC-CFA14-05) will be permanently diverted (as shown in Figure 2) at the viaduct for approximately 170m, due to construction and placement of the embankment on the southern side (south of the viaduct).

4.2.12 The new 170m long channel will be constructed in advance and will be allowed to stabilise and vegetation establish, to control the risk of sediment mobilisation when the River Great Ouse is diverted into the new channel.

4.2.13 The diversion will be designed to ensure that the existing flow and sediment regimes are maintained and acceptable to the Environment Agency. Due to the small scale of this diversion, and the fact that the river is currently impacted some 1km downstream of the crossing by the disused Great Central Main Line, the magnitude of the impact for temporary construction is considered moderate with the scale of remaining impact following mitigation to be negligible, with neutral effect.

4.2.14 There will be no impacts during operation.

Potential impacts of the Westbury viaduct on the River Great Ouse

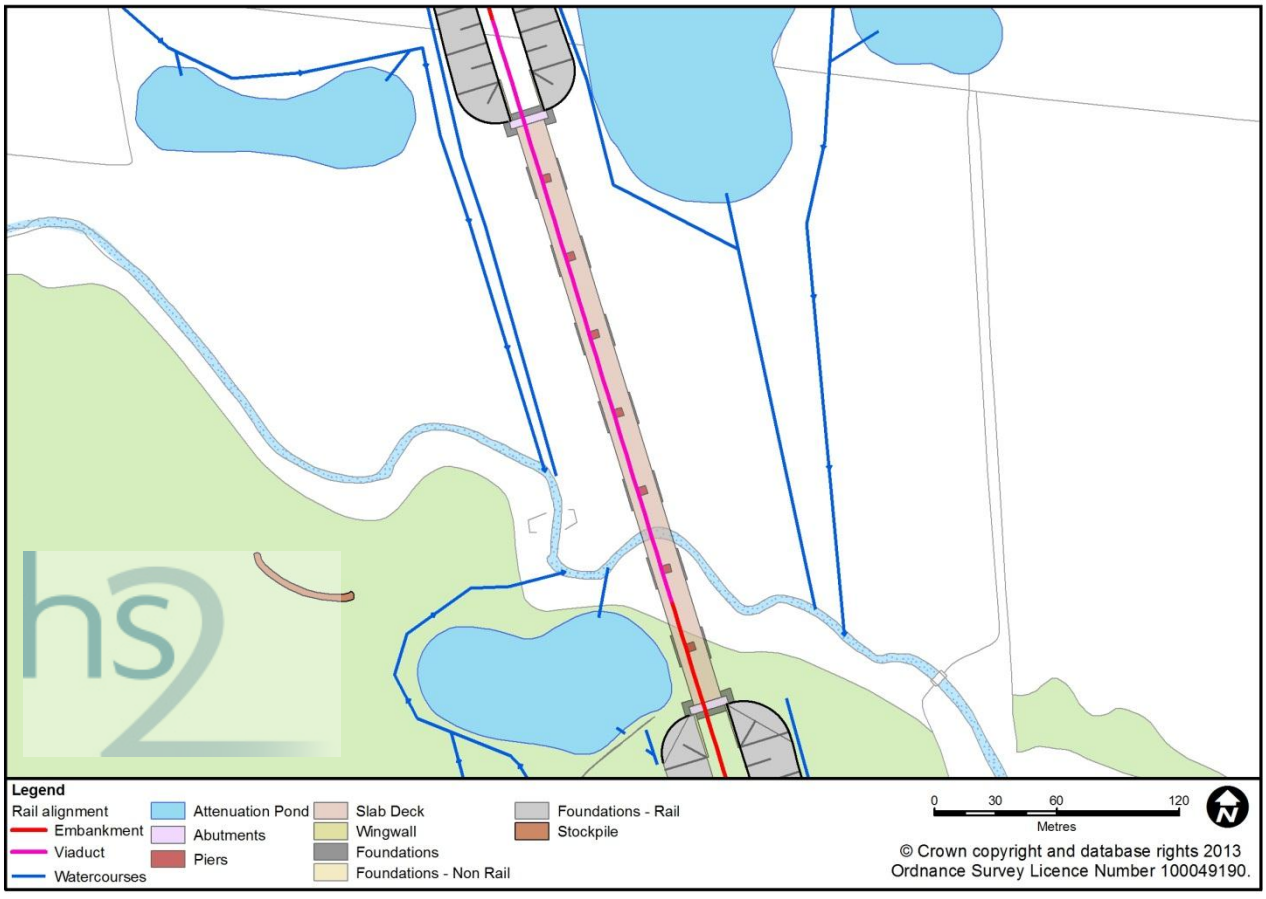
4.2.15 The route will cross the River Great Ouse, west of Westbury (SWC-CFA14-04). The crossing location is within the WFD water body Ouse (GB105033037860), which is designated as a heavily modified water body currently at moderate ecological potential.

4.2.16 The River Great Ouse has an upstream catchment size of approximately 76.7km^2 at the crossing point which is 2% of the total catchment area. There is an existing upstream flow restriction within the catchment of the River Great Ouse throughout the study area, caused by the embankments and underbridges of the disused Great Central Main Line.

4.2.17 At the crossing there will be seven piers which will be located outside of the main channel; thus no temporary or permanent diversion will be required. The viaduct span will be approximately 300m.

4.2.18 As shown in Figure 3, one main channel will pass beneath the proposed viaduct with the closest pier footings approximately 15-20m on either side of the channel.

Figure 3: Channel arrangements and pier footing placements at the Westbury viaduct – SWC-CFA14-04



4.2.19 The magnitude of the impacts on flow and water quality in the River Great Ouse during construction (temporary or permanent) is assessed as negligible as there would be no direct impact on the channel itself. No further mitigation is therefore required.

Potential impacts of the diversions on the unnamed tributary of the Radstone Brook

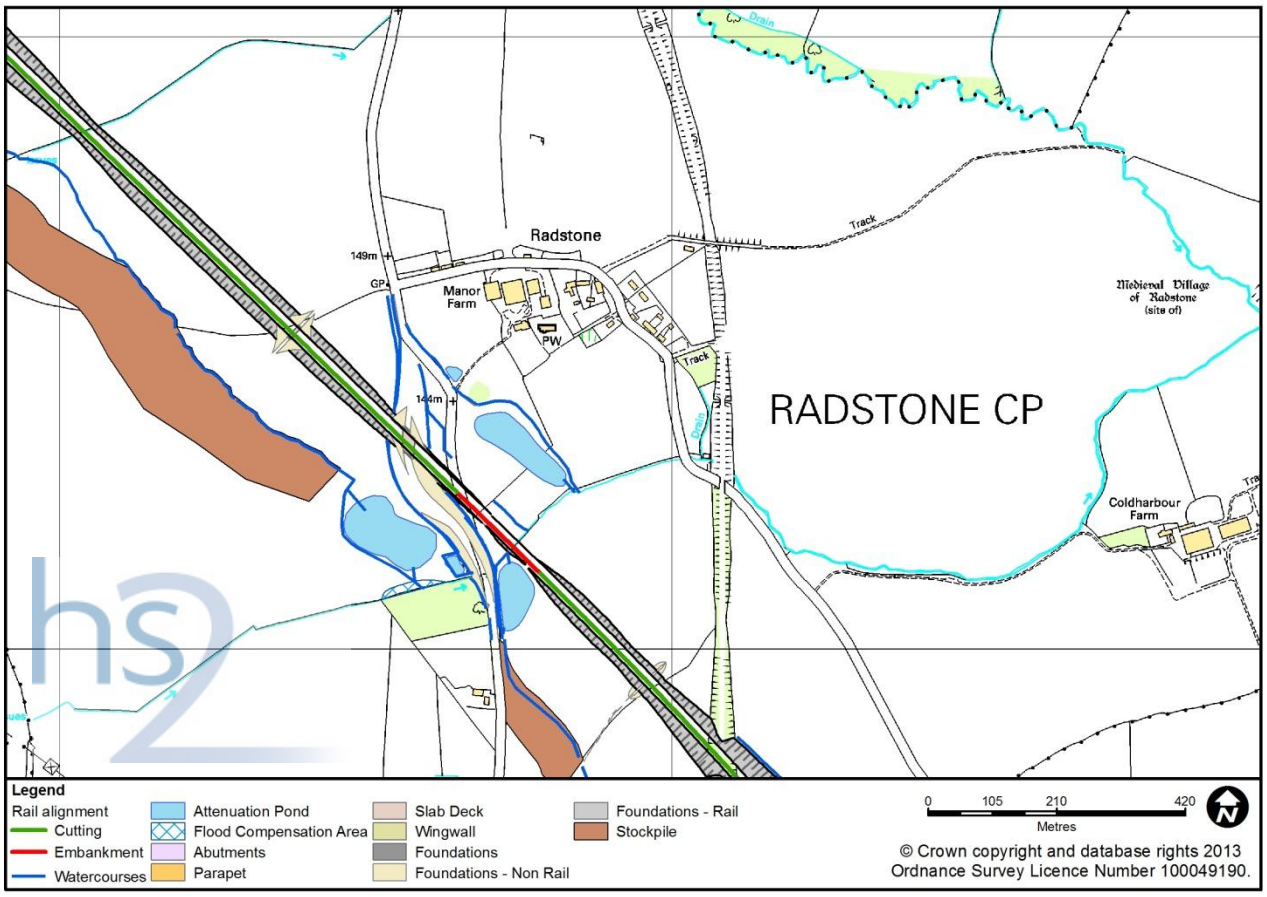
4.2.20 An unnamed tributary of the Radstone Brook will be crossed by the route to the north-west of Radstone (SWC-CFA14-08). At this point there will also be an impact from proposed cuttings and stockpile placement (at SWC-CFA14-19) on the same drain. Currently, the tributary is assumed to be fed by an issue marked on Ordnance Survey (OS) maps approximately 100m west of the route. It is not clear what this issue is fed by, but the aerial photographs show the channel is a narrow ditch between two arable fields. It is likely the ditch receives some seepage from shallow groundwater (the issue) but also drainage from field drains. The ditch flows to the east about 980m before joining the main channel of the Radstone Brook, north of Radstone, from which point the Radstone Brook (GB105033037940) is designated as a heavily modified water body with a moderate ecological status.

4.2.21 The Brackley north cutting is proposed at this part of the route, which will intercept the tributary and affect its current flow regime. The magnitude of impact would be moderate (as the ditch is very small and the Proposed Scheme only affects the very start of the drainage system) with a moderate, significant effect. The current drainage design will divert the tributary to the south, parallel to the route, by approximately 640m in length, which will then feed into a balancing pond and subsequently into the channel of the Radstone Brook to the south of Radstone (Figure 4). During diversion works for the channel, there is potential for temporary effects related to construction activities, for example, a short-term increase in sediment loading on the watercourse and temporary impacts to the flow regime.

4.2.22 The diversion channel will be constructed in advance of the cuttings to meet the requirements of the Environment Agency, including the following mitigation measures: phasing, timing, channel stabilisation and water quality management measures. The remaining impact on the tributary is considered to be moderate, with a moderate, yet significant effect.

4.2.23 While the permanent diversion of the drain is expected to stabilise in regard to flow and water quality, there could potentially be a residual effect on the flow in the remaining channel flowing eastwards. The proposed cuttings and stockpile placement (at SWC-CFA14-19) will potentially affect the dynamics of the spring-fed drain, which will reduce flow into the Radstone Brook. It is considered likely this impact would be minor (not significant) following temporary construction activities. Further monitoring will be implemented with the agreement of the Environment Agency to identify if unforeseen impacts arise, although there is no other practicable mitigation should moderate or major impacts on flow be observed.

Figure 4: Proposed drain diversion of a tributary of the Radstone Brook, north-west of Radstone



Highway drainage assessment

4.2.24 Realignments of one minor road (Radstone Road) and four major roads (A4421, A421-London Road, A422-Brackley Road, and A43-Northampton Road), are required as part of the Proposed Scheme in this area.

4.2.25 The Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2) state that a Design Manual for Roads and Bridges[8] (DMRB) (Department for Transport, 2013) Highways Agency Water Risk Assessment Tool (HAWRAT) assessment is required for realigned roads forecast to exceed both an annual average daily traffic (AADT) value of 10,000 and a heavy goods vehicles (HGV) value of 500. An initial desk study assessment has been carried out which will be further refined at the detailed design stage for the road realignments.

4.2.26 The following assumptions were made in order to carry out this initial assessment:

- the impermeable road area drained was estimated from satellite imagery and OS maps;
- the base flow index of the receiving watercourse has been taken as the

[8] Department for Transport, (2013). Design Manual for Roads and Bridges: http://www.dft.gov.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf

HAWRAT default of 0.5; and

- for the minor watercourses a conservative river width of 1m was estimated from satellite imagery.

The A421, London Road

4.2.27 The A421 is forecast to experience AADT of HGV of greater than 500 and an overall AADT of greater than 10,000. The HAWRAT assessment was undertaken for the A421 discharging to a tributary of the River Great Ouse. HAWRAT Step 1 assesses the quality of the direct highway runoff against permissible threshold values. The A421 fails Step 1 for both pollutants copper and zinc, and for sediment.

4.2.28 Step 2 is a refinement of Step 1, which accounts for the nature and diluting capacity of the receiving water body. The A421 passes the assessment on all accounts at Step 2. No adverse impact on water quality is foreseen, therefore no mitigation is required.

The A422, Brackley Road

4.2.29 The A422 is forecast to experience an overall AADT of less than 10,000 and therefore falls outside the scope of HAWRAT as the effect would be neutral and not significant.

The A43, north of Northampton Road

4.2.30 The A43 (north of Northampton Road) is forecast to experience AADT of HGV of greater than 500 and an overall AADT of greater than 10,000. The HAWRAT assessment was undertaken for the A43 discharging to a tributary of the River Great Ouse. The A43 fails Step 1 for both pollutants copper and zinc, and for sediment.

4.2.31 The A43 passes the assessment on all accounts at Step 2 when dilution by the receiving water body is accounted for. Therefore, no adverse impact on water quality is foreseen and no mitigation is required.

The A4421

4.2.32 The A4421 is forecast to experience AADT of HGV of greater than 500 and an overall AADT of greater than 10,000. The HAWRAT assessment was undertaken for the A4421 discharging to a local stream which feeds into the Padbury Brook. The A4421 fails Step 1 for both pollutants copper and zinc, and for sediment.

4.2.33 The A4421 fails Step 2 for both pollutants copper and zinc, and for sediment so mitigation measures will be required.

4.2.34 Step 3 allows an assessment of the effects of (i) restriction on the maximum outfall discharge rate to attenuate road runoff, (ii) treatment of road runoff to reduce pollutant concentrations and (iii) settlement of sediments in the road runoff to reduce annual sediment volume. Nominal mitigation values of 50% treatment have been assumed in this assessment. This nominal mitigation value is sufficient to bring the water quality within permissible limits and induce negligible impact on the water environment.

4.2.35 Appropriate mitigation will be provided to address the risks to the receiving watercourse (for both flow and water quality) and will be selected using the DMRB (particularly HA103/06) and Construction Industry Research and Information

Association (CIRIA) guidance[9]. The mitigation measures will be finalised at the detailed design stage. Remaining impacts will be negligible and the effect neutral as a result.

[9] Murname, E., Heap, A. and Swain, A., 2006, C648 Control of Water Pollution from Linear Construction Sites, CIRIA, London, UK.

5 Site specific groundwater assessments

5.1 Summary of assessment

5.1.1 Table 7 summarises the potential impacts to hydrogeology (groundwater), abstractions, water dependent habitats and surface water/groundwater interactions. Only those impacts and effects that are classed as significant are presented in Volume 2, CFA Report 14, Section 13.4.

Table 7: Summary of potential impacts to groundwater, abstractions, water dependent habitats and surface water/groundwater interactions

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Hydrogeology (groundwater)									
Alluvium (Secondary A aquifer)	Moderate	Westbury viaduct Turweston viaduct	Although there will be some slight localised disturbance of groundwater flow around the piles, the piles will not completely block flow within the aquifer as a whole. Any diverted groundwater flow would probably enter the rivers at these points which is where the groundwater would discharge anyway. There is the potential for minor contamination to shallow groundwater due to spills during construction of the viaducts.	Minor impact Slight effect (Not significant)	The mitigation measures set out within the draft CoCP will ensure that the construction of the viaduct will not create pathways to the shallow groundwater and that construction materials are stored and applied appropriately so as not to cause contamination of shallow groundwater.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Glaciofluvial deposits (Secondary A aquifer) Great Oolite Group (Cornbrash Formation, Forest Marble Formation,	Moderate (Glaciofluvial deposits) High (White Limestone Formation)	Barton to Mixbury cutting	The groundwater elevation is considered to be at or slightly above the base of the cutting and hence some dewatering may occur. The overall impact on the hydrogeological regime is considered to be not	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
White Limestone Formation) (Secondary and Principal aquifers)			significant. Further discussion is contained in Section 5.2 of this report.						
Glaciofluvial Deposits (Secondary A aquifer) Head (Secondary undifferentiated aquifer) White Limestone Formation (Principal aquifer)	Moderate (Glaciofluvial Deposits, Head) High (White Limestone Formation)	Mixbury cutting	No information on the groundwater elevation in this area is currently available. The lowest elevation of the Proposed Scheme in this cutting is approximately 109m AOD. Springs are marked on OS maps close to the 95m AOD contour at the base of the hillside suggesting that groundwater levels are likely to be below the base of the cutting. Consequently it is unlikely that there will be an impact on groundwater flow.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Great Oolite Group: Forest Marble Formation (Secondary aquifer) White Limestone Formation (Principal aquifer) Rutland Formation (Secondary aquifer) Taynton Limestone Formation (Principal aquifer) Horsehay Sand Formation (Secondary aquifer)	Moderate (Forest Marble, Rutland and Horsehay Sand Formations) High (White Limestone and Taynton Limestone Formations)	Turweston cutting	The cutting will pass through the Great Oolite Group. The aquifer formations within the Great Oolite are considered to be in hydraulic connectivity with one another and so are considered as a single groundwater receptor. The groundwater table is above the base of the cutting and dewatering will therefore occur, although there will be a remaining 10m of saturated aquifer below the cutting to ensure the hydrogeological regime is not adversely affected overall. Further detailed discussion is presented in Section 5.2 of this report.	Minor impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Glaciofluvial deposits (Secondary A aquifer) Sharp's Hill Formation (Secondary A aquifer) Rutland Formation (Secondary B aquifer) Taynton Limestone Formation (Principal aquifer) Blisworth Limestone Formation (Principal aquifer)	Moderate (Glaciofluvial deposits, Sharps' Hill Formation) High (Taynton and Blisworth Limestone Formations)	Brackley south cutting	The Glaciofluvial deposits are considered to be in hydraulic connectivity with the underlying Great Oolite aquifers (Taynton and Blisworth Limestones and Sharp's Hill Formation). The groundwater table will be at or slightly above the base of the cutting and as such dewatering and some disruption to groundwater flow will occur but it is not considered to be significant. See Section 5.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Glaciofluvial deposits (Secondary A aquifer) Rutland Formation (Secondary B aquifer) Blisworth Limestone Formation (Principal aquifer)	Moderate (Glaciofluvial deposits and Rutland Formation) High (Blisworth Limestone)	Brackley north cutting	The groundwater elevation has been inferred to be below the base of the cutting. As such no groundwater will be affected by the cutting.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Glaciofluvial deposits (Secondary A aquifer) White Limestone Formation (Principal aquifer) Rutland Formation (Secondary B aquifer) Taynton Limestone Formation (Principal aquifer) Forest Marble Formation (Secondary aquifer)	Moderate (Secondary aquifers) High (Principal aquifers)	Five stockpiles (temporary earthworks), east of Brackley	There are five stockpiles in this study area that overly the Great Oolite Group aquifer. There is potential for constituents arising from the excavated stockpiled material to reduce the quality of groundwater in the Great Oolite aquifers. See Section 5.2 of this report for further discussion	Moderate impact Moderate effect (Significant)	Suitable quality criteria will be defined prior to material being placed. The draft CoCP (Section 15) defines the controls and guidance that should be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. Monitoring water quality will also be implemented as outlined in the draft CoCP Section 16	Negligible impact Neutral effect (Not significant)	Not required	None	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Abstractions									
Unlicensed groundwater abstraction at Mixbury Hall	High	Mixbury cutting	The groundwater elevation has been inferred to be below the base of the cutting. As such no groundwater will be affected by the cutting and thus flow to the abstraction should be unaffected.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Surface water/groundwater interactions and water dependant habitats									
A minor watercourse rising to the north-west of Westbury and to the East of Turweston	Moderate	Turweston cutting	This stream is at an elevation of 120m AOD near its source at Oatleys Farm, falling to approximately 110m AOD to the south-east of Grove Farm. Groundwater levels at Turweston Fields are assessed to be approximately 114m AOD, suggesting that this stream is above the groundwater level in its upper reaches and is unlikely to be impacted by the Proposed Scheme. In addition to this the calculations included in Section 5.2 of this report indicate that this watercourse is outside of the radius of influence of the Turweston cutting.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Turweston Manor Grassland LWS	Moderate	Turweston cutting	The Turweston Manor Grassland is designated for floodplain grazing marsh and lowland calcareous grassland. The Turweston cutting will act as a groundwater sink and would draw in groundwater that would otherwise flow towards the LWS. The natural direction of groundwater flow and the calculated zone of influence indicate that the effect on groundwater flow to the LWS is likely to be negligible. Refer to Section 5.2 of this report for further discussion.	Minor impact Slight effect (Not significant)	Not required	Minor impact Slight effect (Not significant)	None	Minor impact Slight effect (Not significant)	Construction (permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Turweston Wetland Turweston Carr	Moderate	Turweston cutting	The Turweston Wetland and Carr are small areas of marshland and wet woodland to the south-west of Turweston, approximately 800m from the Proposed Scheme. There are some small springs and issues in the area which suggests that this wetland is at least in part supported by groundwater seepage. Although there will be some loss of flow to the springs and the wetland/carr, there should be some flow under the cutting and within the catchment to support the general groundwater flow regime to the springs and wetland/carr at Turweston. See Section 5.2 of this report for further details.	Minor impact Slight effect (Not significant)	Monitoring of groundwater elevations, in line with the draft CoCP, will ensure the baseline conditions are better understood before construction but also to monitor the magnitude of any potential effects on groundwater levels and the wetland as a result of the cutting.	Minor impact Slight effect (Not significant)	None	Minor impact Slight effect (Not significant)	Construction (permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
River Great Ouse	High	Turweston cutting Mixbury cutting	Where the River Great Ouse will be crossed by the route, the river overlies the Whitby Mudstone Formation which is unproductive strata. The assessments indicate that the spring fed streams to the River Great Ouse will not be significantly impacted. See Section 5.2 of this report for further discussion	Negligible impact Neutral effect (Not significant)	Drainage from the cuttings would be returned to the River Great Ouse or its tributaries via balancing ponds.	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable
Spring, minor watercourse and large pond south of Westbury	Moderate	Mixbury cutting	These features are at an elevation of about 95m AOD, 15m below the lowest elevation of the Mixbury cutting. It is anticipated that groundwater levels are well below the base of the Mixbury cutting and there will be a no impact on groundwater flows and levels as a result of the cutting.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	None	Not applicable	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Three springs/issues to the north-east and east of Brackley	Low	Brackley south cutting	These springs will not be affected by the cutting as groundwater flow to these springs will not be significantly altered by the cutting. Further details are provided in Section 5.2 of this report.	Minor impact Slight effect (Not significant)	Monitoring of groundwater elevations, in line with the draft CoCP, will ensure that the spring elevations and seasonal variations are well understood before the final design stage.	Minor impact Slight effect (Not significant)	None	Minor impact Slight effect (Not significant)	Construction (permanent)
One spring/issue to the east of Brackley at elevation 115m (south-west of cutting)	Low	Brackley south cutting	Up to 60% of the catchment contributing flow to this spring will be affected by the cutting and a reduction in aquifer thickness. Further details are provided in Section 5.2 of this report.	Moderate impact Slight effect (Not significant)	Monitoring of groundwater elevations, in line with the draft CoCP, will ensure that the spring elevations and seasonal variations are well understood before the final design stage.	Moderate impact Slight effect (Not significant)	None	Moderate impact Slight effect (Not significant)	Construction (permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Helmdon Disused Railway SSSI	High	Brackley south cutting	The Brackley south cutting will be approximately 3.6m below the existing railway SSSI. The cutting will affect groundwater flow and levels in the vicinity of the cutting. The SSSI designation is not based on groundwater dependent species and the loss of groundwater will not adversely affect the SSSI. See Section 5.2 of this report for further discussion.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)
A small stream rises to the south-west of Radstone and flows into a tributary of the River Great Ouse	Moderate	Brackley south cutting	The stream is likely to be in connectivity with groundwater in the Great Oolite Group. However, any significant impact to groundwater flow and levels will not extend to the stream. See Section 5.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	Track and land drainage from the Brackley north cutting will be discharged to this watercourse along with land drainage from the area to the south of the Brackley south cutting.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Issue that feeds unnamed tributary (drain) of the Radstone Brook	Moderate	Brackley north cutting	The issue is likely to rise from the glaciofluvial deposits underlying the Till and likely to be in hydraulic connectivity with the underlying Blisworth Limestone Formation. The groundwater level will be below the base of the cutting and hence groundwater flow will not be disrupted. There will be a channel diversion for this drain that will affect the surface water flows. The effect on the surface water flows in the drain is discussed in Table 5 of this report.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)

5.2 Detailed assessments

Assessment of cuttings

5.2.1 At a location where a cutting extends below the groundwater table, the cutting will require some dewatering during construction. After construction the cutting is likely to act as a groundwater sink.

5.2.2 In order to establish the extent to which dewatering may affect the groundwater flow regime Sichardt's formula has been applied following guidance in CIRIA C515 (2000) Groundwater control – design and practice (CIRIA, 2000)[10] and CIRIA C113 (1986) Control of groundwater for temporary works (CIRIA, 1986)[11]. Sichardt's formula is presented below:

$$Lo = C \times h \times \sqrt{k}$$

Where; Lo = distance of influence from linear structure (m)

k = hydraulic conductivity (m/s)

h = drawdown (m)

C = empirical factor taken to be 2,000

5.2.3 The calculated zone of influence should be considered with caution as the direction of groundwater flow and the presence of groundwater divides will influence the extent to which groundwater levels and flow will be affected.

[10] CIRIA, 2000, CIRIA C515 Groundwater control – design and practice
[11] CIRIA, 1986, CIRIA C113 Control of groundwater for temporary works

5.2.4 Figure 5 illustrates schematically how Sichardt's formula has been applied.

Figure 5: Application of Sichardt's formula

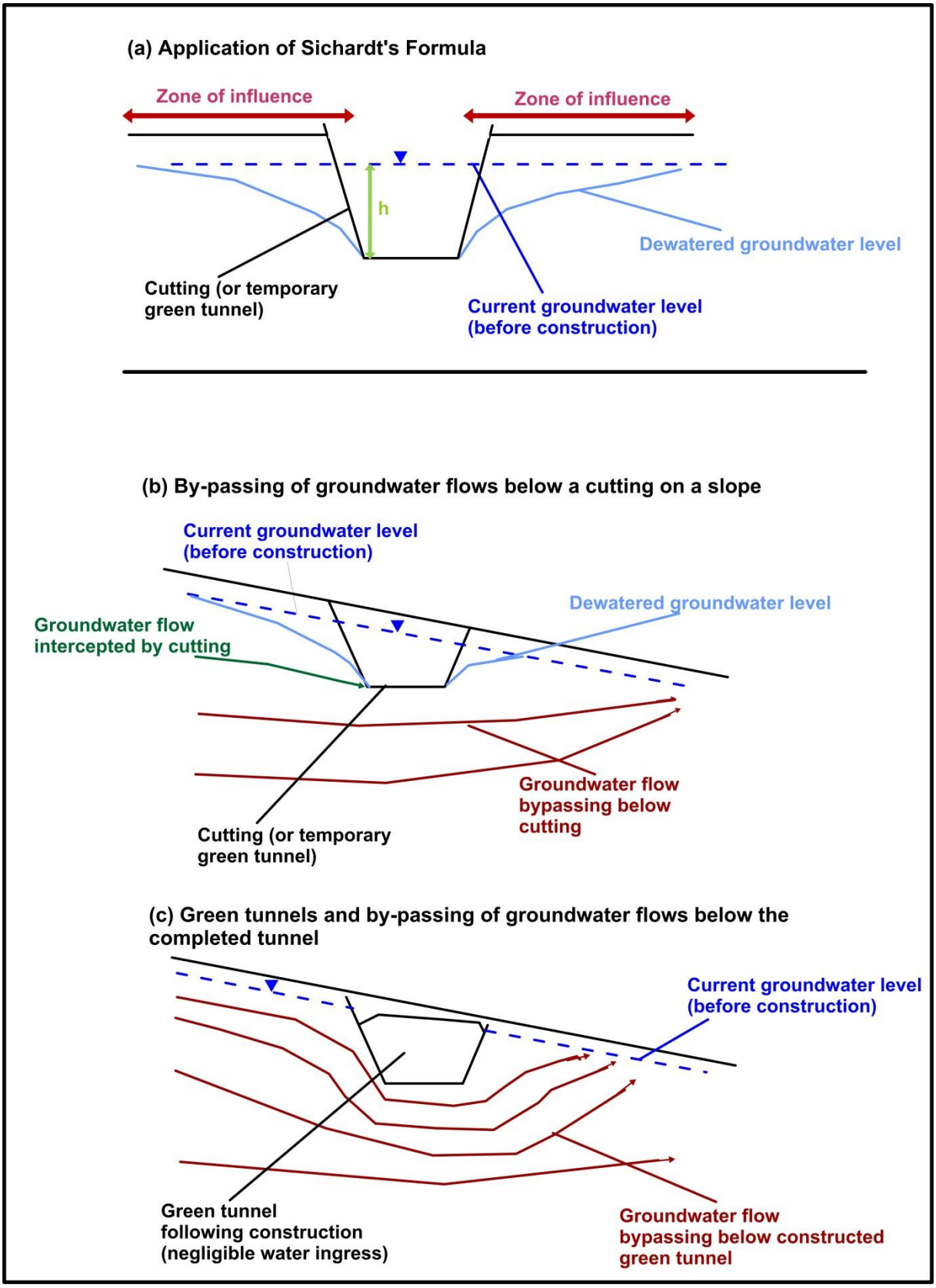


Table 8: Summary of cuttings in the study area

Cutting name	Geology penetrated	Groundwater elevation	Effect on groundwater resources	Mitigation
Barton to Mixbury cutting	Made Ground Alluvium (Secondary aquifer) Glacial Till (Unproductive strata) Glaciofluvial Deposits (Secondary aquifer) White Limestone Formation (Principal aquifer) Forest Marble Formation (Secondary aquifer) Cornbrash Formation (Secondary aquifer)	Water table at or above the base of the cutting in places but most of the cutting is above the groundwater table.	Potential to affect groundwater flow to springs. Effect will be not significant. See Barton to Mixbury cutting sub-section that follows for further details	Not required.
Turweston cutting	Glacial Till (Unproductive strata) Forest Marble Formation (Secondary aquifer) White Limestone Formation (Principal aquifer) Rutland Formation (Secondary aquifer) Taynton Limestone Formation (Principal aquifer) Horsehay Sand Formation (Secondary aquifer)	Water table above the cutting	Issues and springs around Turweston Turweston Manor Grassland LWS Turweston Wetland and Turweston Carr See Turweston south cutting sub-section that follows for further details	Any groundwater intercepted by this cutting would be returned to ground or to local watercourses via balancing ponds.
Mixbury cutting	Glaciofluvial Deposits (Secondary A aquifer) Head (Secondary undifferentiated aquifer) White Limestone Formation (Principal aquifer)	Water table likely to be at or below the cutting	No impact to groundwater, which is below the cutting	None required.

Cutting name	Geology penetrated	Groundwater elevation	Effect on groundwater resources	Mitigation
Brackley south cutting	Glacial Till (Unproductive) Glaciofluvial deposits (Secondary A aquifer) Great Oolite Group (Principal aquifer)	Water table above cutting, especially in the south-east	Potential to affect groundwater flow and Helmdon Disused Railway SSSI See Brackley south cutting sub-section that follows for further details	Any groundwater intercepted by this cutting would be returned to ground or to local watercourses via balancing ponds, where possible.
Brackley north cutting	Glacial Till (Unproductive) Great Oolite Group (Principal aquifer)	Water table likely to be below the cutting	No impact to groundwater, which is below the cutting	None required.

Barton to Mixbury cutting

5.2.5 A summary of the cutting details are provided in Table 9.

Table 9: Summary of Barton to Mixbury cutting detailed groundwater assessment

Cutting parameters	Parameter details
Length (km)	4.1
Maximum depth (m)	10.0
Strata intercepted	Alluvium (Secondary aquifer) Glacial Till (Unproductive strata) Glaciofluvial Deposits (Secondary aquifer) White Limestone Formation (Principal aquifer) Forest Marble Formation (Secondary aquifer) Cornbrash Formation (Secondary aquifer)
Lowest track level (m AOD)	104.4 (rises to 119.1).
Groundwater level(s) (m AOD)	Unknown, no monitoring data available, inferred from spring elevations and surface water features. The southernmost 0.45km of the cutting is likely to be below the groundwater table. Central 3.2km groundwater elevation likely to be at or slightly above the base of the cutting. The next 0.225km are likely to be below the water table.The final 0.225km will be largely above the water table.
Principal receptors	Local springs close to the 115m AOD topographic contour (from OS maps). One issue within 1km of route, west of Barton Hartshorn.

5.2.6 No information on the groundwater elevation in this area is currently available. Springs are marked on OS maps between the 105 - 115m AOD contours. The springs generally appear to the east and west of the route at a distance greater than 1km. There is one issue south-west of Barton Hartshorn at the southernmost part of the cutting, which will be 780m north-east of the cutting in the study area. Figure 6 shows a cross section of the cutting with the inferred groundwater elevation.

5.2.7 Although there is no groundwater elevation data available from monitoring, spring elevations and the elevation of watercourses in hydraulic continuity with groundwater have been used to determine the approximate water table elevation. The water table is inferred to be at or marginally above the cutting for the majority of the cutting (central 3.2km) and above the cutting in the southernmost 0.45km. The 0.225km of cutting to the north of the central zone will be below the water table and the northernmost 0.225km will be above the water table. The glaciofluvial deposits are considered to underlie the Glacial Till and will be in hydraulic connectivity with the underlying Great Oolite Group (White Limestone Formation, Forest Marble Formation and Cornbrash Formation).

5.2.8 There is therefore potential for groundwater flow to be disturbed, both during and after construction within the central section of the cutting, when the cutting may act as a groundwater sink.

5.2.9 Sichardt's equation has been applied in order to determine an approximate zone of influence. The hydraulic conductivity has been taken from the British Geological Survey (BGS) (1997)[12] for the Great Oolite Group (i.e. 0.00055 m/s). The maximum dewatering is likely to be 4m (based on the cutting elevation and assumed groundwater elevation). As such, the maximum distance of the zone will be approximately 180m either side of the route. The maximum impact will be where the difference between the water table elevation and cutting elevation is greatest, i.e. on the southern and northern sections of the cutting.

5.2.10 Figure 7 illustrates the extent of the zone of influence. There will be some disruption to groundwater flow, which is currently inferred to be towards the south-east to the south of a groundwater divide (as shown on Figure 7) and to the north-west to the north of the divide. The zone of influence, however, demonstrates that the issues near Barton Hartshorn will not be adversely affected. Land drainage will be in place that allows captured drainage water to be discharged to local watercourses to the north and south of the cutting, ensuring there will be no adverse effect on surface watercourses. In conclusion, there will not be a significant effect on groundwater flows or springs/issues within 1km of the cutting.

[12] BGS, 1997. *The aquifer properties of major aquifers in England and Wales.* Hydrogeology Group Technical Report WD/97/34, Environment Agency R&D Publication 8

Figure 6: Schematic cross-section of the Barton to Mixbury cutting and inferred groundwater elevations.

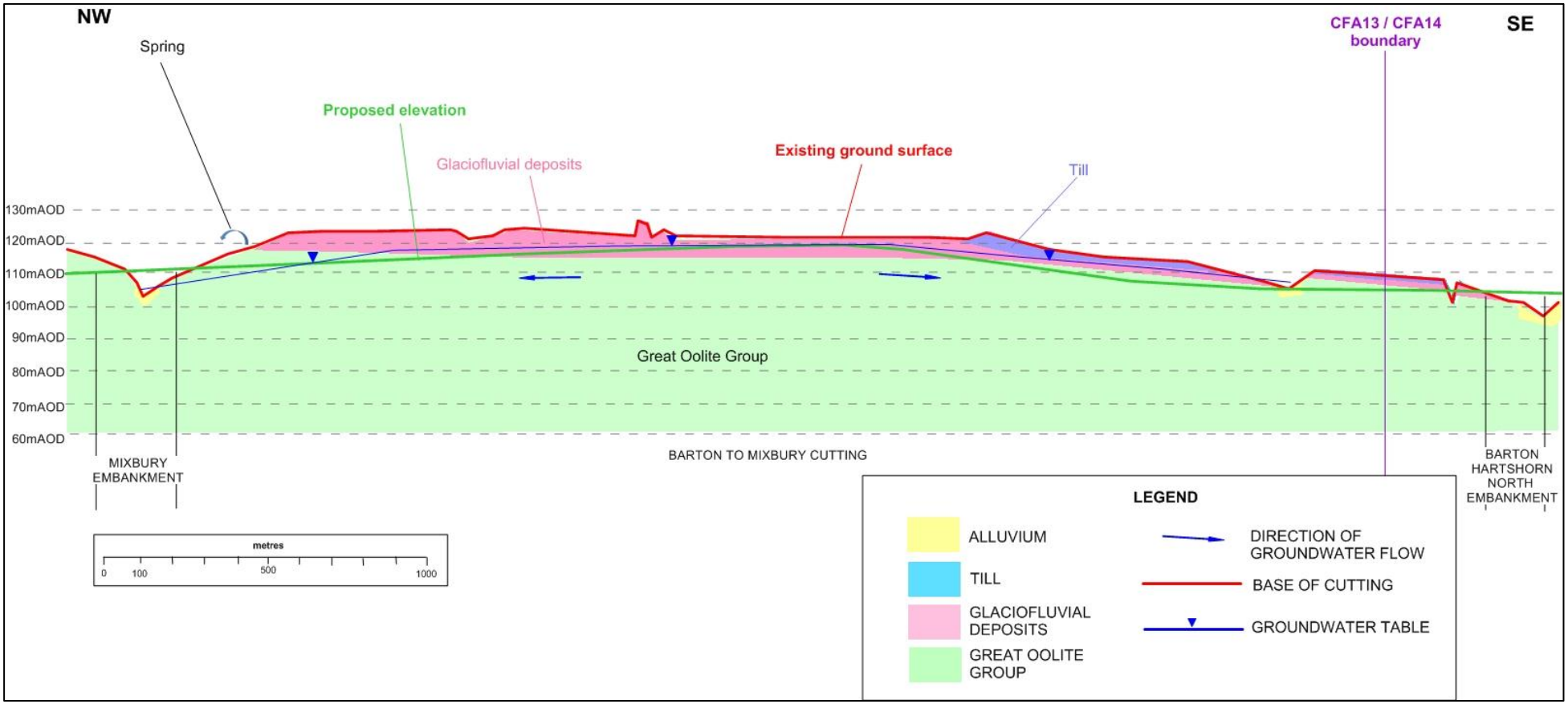
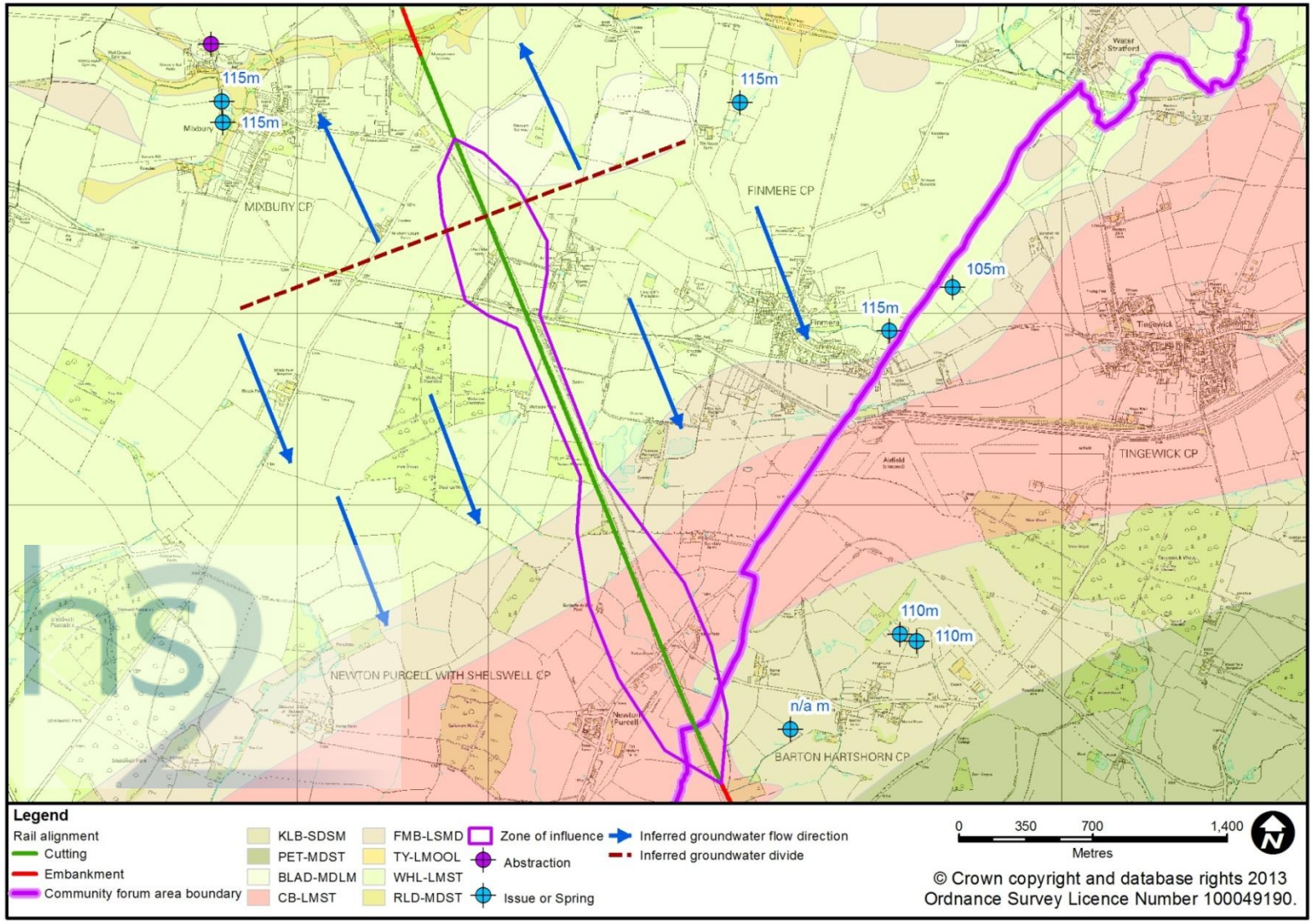


Figure 7: Schematic representation of the zone of influence around the Barton to Mixbury cutting[13].



[13] Key to geological units in legend: KLB-SDSM = Kellaways Formation, PET-MDST = Peterborough Member, BLAD-MDLM = Blisworth Limestone Formation, CB-LMST = Cornbrash Formation, FMB-LSMD = Forest Marble Formation, TY-LMOOL = Taynton Limestone Formation, WHL-LMST = Whitby Limestone Formation and RLD-MDST = Rutland Formation.

Turweston cutting

5.2.12 A summary of the cutting details are provided in Table 10.

Table 10: Summary of Turweston cutting detailed groundwater assessment

Cutting parameters	Parameter details
Length (km)	2.34
Maximum depth (m)	20.1
Strata intercepted	Glacial Till (Unproductive strata) Forest Marble Formation (Secondary aquifer) White Limestone Formation (Principal aquifer) Rutland Formation (Secondary aquifer) Taynton Limestone Formation (Principal aquifer) Horsehay Sand Formation (Secondary aquifer) A major fault crosses the line of the route in this cutting
Lowest track level (m AOD)	108.4
Groundwater level(s) (m AOD)	115 - 125m
Principal receptors	Issues and springs around Turweston. Turweston Manor Grassland LWS. Turweston Carr (see Table 7) Turweston Wetland (see Table 7)

5.2.13 The Turweston cutting will pass through the Great Oolite Group Principal aquifer and the Glaciofluvial deposits that overlie the Great Oolite Group. The Great Oolite Group is 20 - 30m thick through the area of cutting and is underlain by the Whitby Mudstone (Unproductive strata). There is a geological fault located in the centre of the cutting which appears to displace the Forest Marble Formation. For the purposes of determining the approximate zone of influence the fault is assumed not to affect the assessment significantly particularly as there is considered to be hydraulic connectivity between the majority of formations in the Great Oolite Group. The glaciofluvial deposits and Great Oolite Formation are also considered to be in hydraulic connectivity.

5.2.14 There are two springs to the south-west of Turweston, approximately 830m west of the cutting, which appear to issue at the boundary between the White Limestone Formation and Rutland Mudstone Formation, and in the Taynton Formation. The springs are at an elevation of 110 and 115m AOD. There are no springs noted on OS mapping in reasonable vicinity of the southern end of the cutting. The absence of springs indicates that groundwater is unlikely to be present in significant quantities in the area.

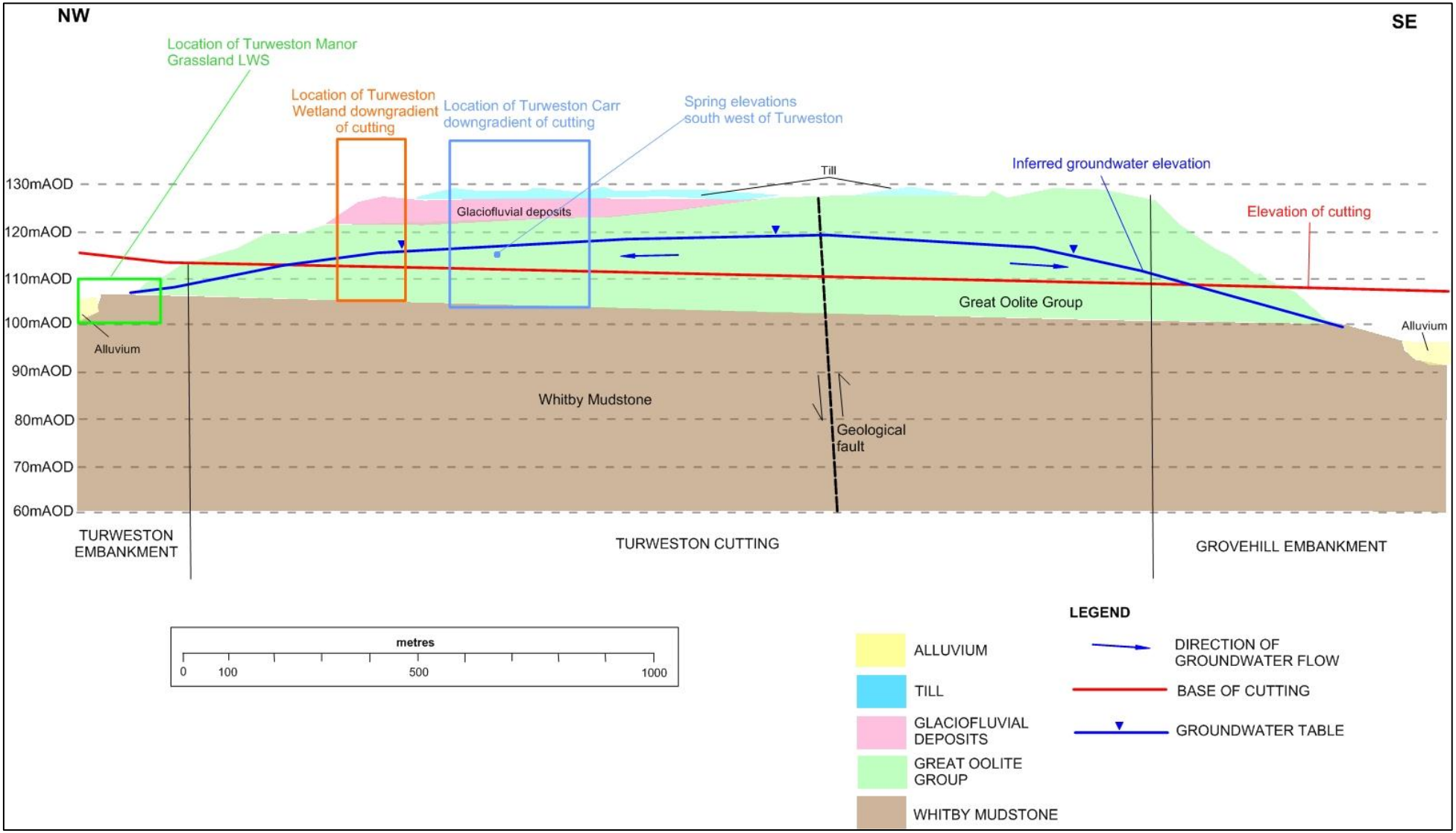
5.2.15 The Turweston Manor Grassland LWS is located to the north and south of the cutting, adjacent to the River Great Ouse. A quarter of the LWS will be on the southern side of the cutting and the remainder to the north. Aerial photographs show evidence of one spring/seepage in the Turweston Manor Grassland LWS on the north side of the cutting.

5.2.16 Groundwater level data for the immediate vicinity of the cutting is limited. Water levels in a borehole at Turweston Fields approximately 330m east of the route are recorded as being approximately 18m below ground level (approximately 114m AOD).

5.2.17 There are insufficient data available to accurately determine the natural groundwater flow direction, or the flow that might be intercepted by the cutting. However, the position of the water table and flow direction can be inferred from topography and levels of local surface watercourses, together with the groundwater level at Turweston Fields. The water table is likely to be above the cutting for the majority of the route and only below the cutting at the northern and southern extremities. Figure 8 illustrates the inferred elevation of the water table relative to the cutting.

5.2.18 It is assumed that groundwater flow will follow topography and is towards the River Great Ouse in the area around Turweston, i.e. to the north-west.

Figure 8: Inferred groundwater levels at the Turweston cutting.



5.2.19 In order to appreciate the approximate extent of influence on groundwater flows, Sichardt's equation has been applied. The hydraulic conductivity of the Great Oolite Formation (0.00055m/s) was derived using information in the British Geological Survery (BGS, 1997)[12]. A maximum dewatering depth of 10m has been considered, based on the inferred groundwater elevation and the cutting elevation. As a result, the maximum extent of influence will be approximately 500m in the centre of the cutting, where the drawdown below the groundwater table is greatest, as shown on Figure 8 and Figure 9.

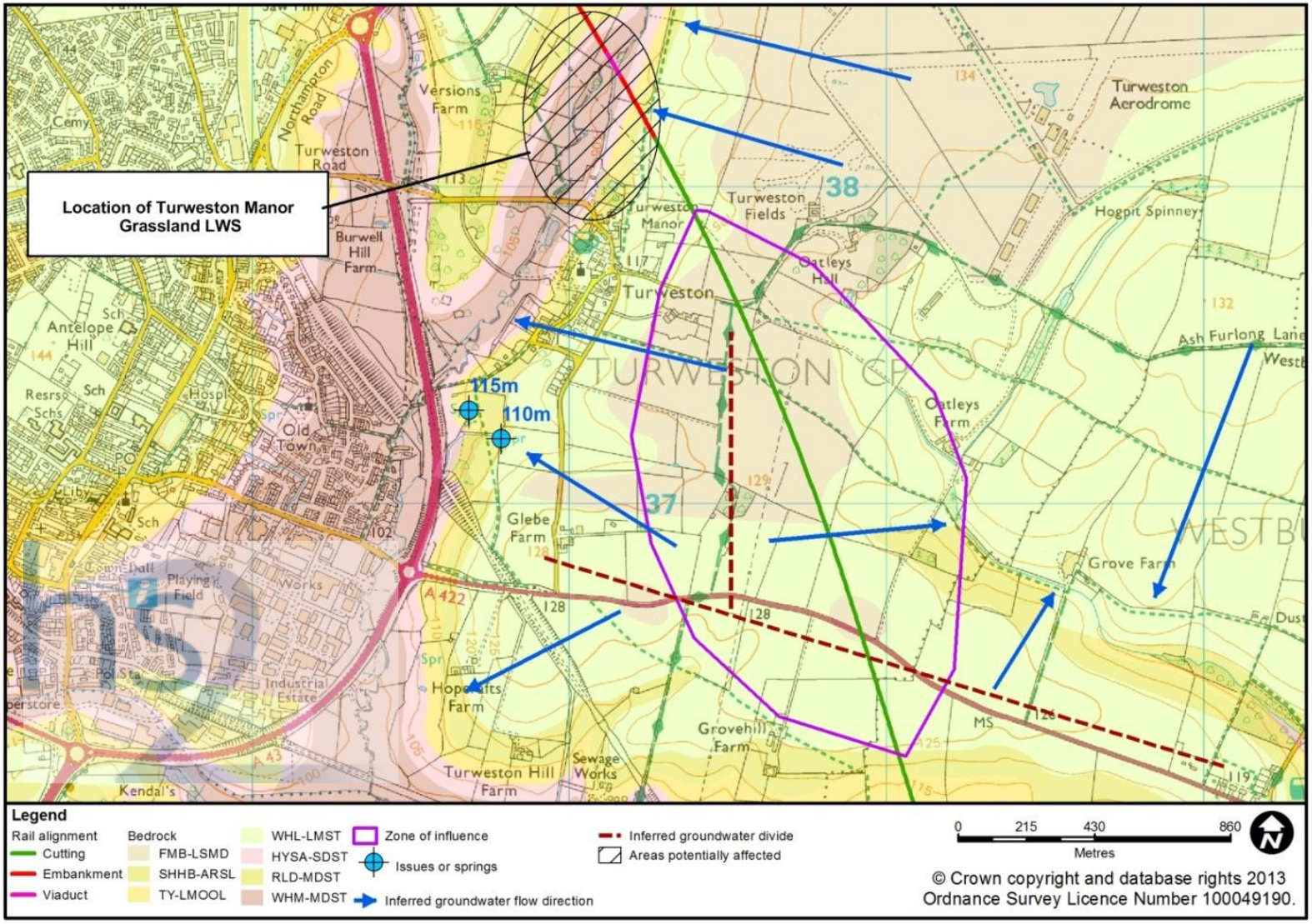
5.2.20 The dewatering at the cutting will affect the position of inferred groundwater divides, shown on Figure 9. There will, therefore, be an impact on the catchment supplying the springs to the west of the cutting and potentially the groundwater elevation at Turweston Wetland and Turweston Carr. The base of the Great Oolite Group is inferred, from the outcrop of the underlying Whitby Mudstone, to be approximately 10m below the cutting. Although there will be a loss of groundwater flow as a result of interception in the cutting (and resulting changes in the groundwater divide and thus catchment area), there should be some residual flow under the cutting to support groundwater discharges to the springs and wetland/carr at Turweston (see Figure 8). Monitoring of groundwater elevations, in line with the CoCP, will ensure the baseline conditions are better understood, together with the magnitude of any potential effects of the cutting.

5.2.21 The Turweston Manor Grassland LWS is located either side of the cutting. However, the zone of influence of the northern end of the cutting does not intrude on the LWS, as indicated in Figure 9. Hence the existing groundwater flow regime to the northern part of the LWS should not be adversely affected. The section of the LWS south of the cutting should also not be affected as the groundwater level is assessed as being below the base of the cutting (see Figure 8).

5.2.22 All groundwater intercepted by this cutting would be returned to ground or to local watercourses via the drainage design and attenuation ponds. Furthermore, at the ends of the cuttings, where the water table falls below the route, drainage flows will tend to soak away and recharge the aquifer.

5.2.23 In summary, although groundwater flow local to the cutting will be disturbed, there are unlikely to be significant effects on the Turweston Manor Grassland LWS. There should also be some residual flow under the cutting to support groundwater discharges to the springs and wetland/carr at Turweston.

Figure 9: Zone of influence of Turweston cutting[14]



[14] Key to geological units in legend: FMB-LSMD = Forest Marble Formation, SHHB-ARSL = Sharp's Hill Formation, TY-LMOOL = Taynton Limestone Formation, WHL-LMST = Whitby Limestone Formation, HYSA-SDST = Horsehay Sand Formation, RLD-MDST = Rutland Formation and WHM-MDST = Whitby Mudstone Formation.

Brackley south cutting

5.2.24 A summary of the cutting details are provided in Table 11.

Table 11: Summary of Brackley south cutting detailed groundwater assessment

Cutting parameters	Parameter details
Length (km)	1.5
Maximum depth (m)	17.9
Strata intercepted	Glaciofluvial deposits (Secondary A aquifer) Sharp's Hill Formation (Secondary A aquifer) Taynton Limestone Formation (Principal aquifer) Blisworth Limestone Formation (Principal aquifer)
Lowest track level (m AOD)	121.2
Groundwater level(s) (m AOD)	130 - 140m
Principal receptors	Springs/issues south-west of southern end of cutting and west of the cutting (north of The Old Glebe). Helmdon Disused Railway SSSI.

5.2.25 The existing railway cutting is a designated SSSI and cuts through the Glacial Till and Glaciofluvial deposits into the Great Oolite.

5.2.26 The proposed Brackley south cutting will largely pass through the Great Oolite Group, comprising a small outcrop of Sharp's Hill Formation and Taynton and Blisworth Limestone Formations. The Great Oolite Group is shallower in the north of the cutting and is 15 to 25m thick through the area of cutting. It is underlain by the Whitby Mudstone (Unproductive). The Glaciofluvial deposits and Great Oolite Formation are considered to be in hydraulic connectivity.

5.2.27 There are four springs/issues within 1km of the cutting;

- an issue 390m south-west of route at Versions Farm Bungalow at 120m AOD;
- an issue 530m south-west of route at Versions Farm Bungalow at 115m AOD;
- a spring 200m south-east of route at 115m AOD; and
- a spring 845m west of route at 140m AOD.

5.2.28 A site inspection in June 2013 noted the presence of water in the base of the existing railway cutting, which suggests that the water table is close to the bottom of the existing cutting.

5.2.29 Using this information and the surface watercourse elevations that are considered to be in continuity with groundwater, the groundwater elevations have been inferred to be between 130 and 140m AOD (see Figure 10), with the greatest difference between

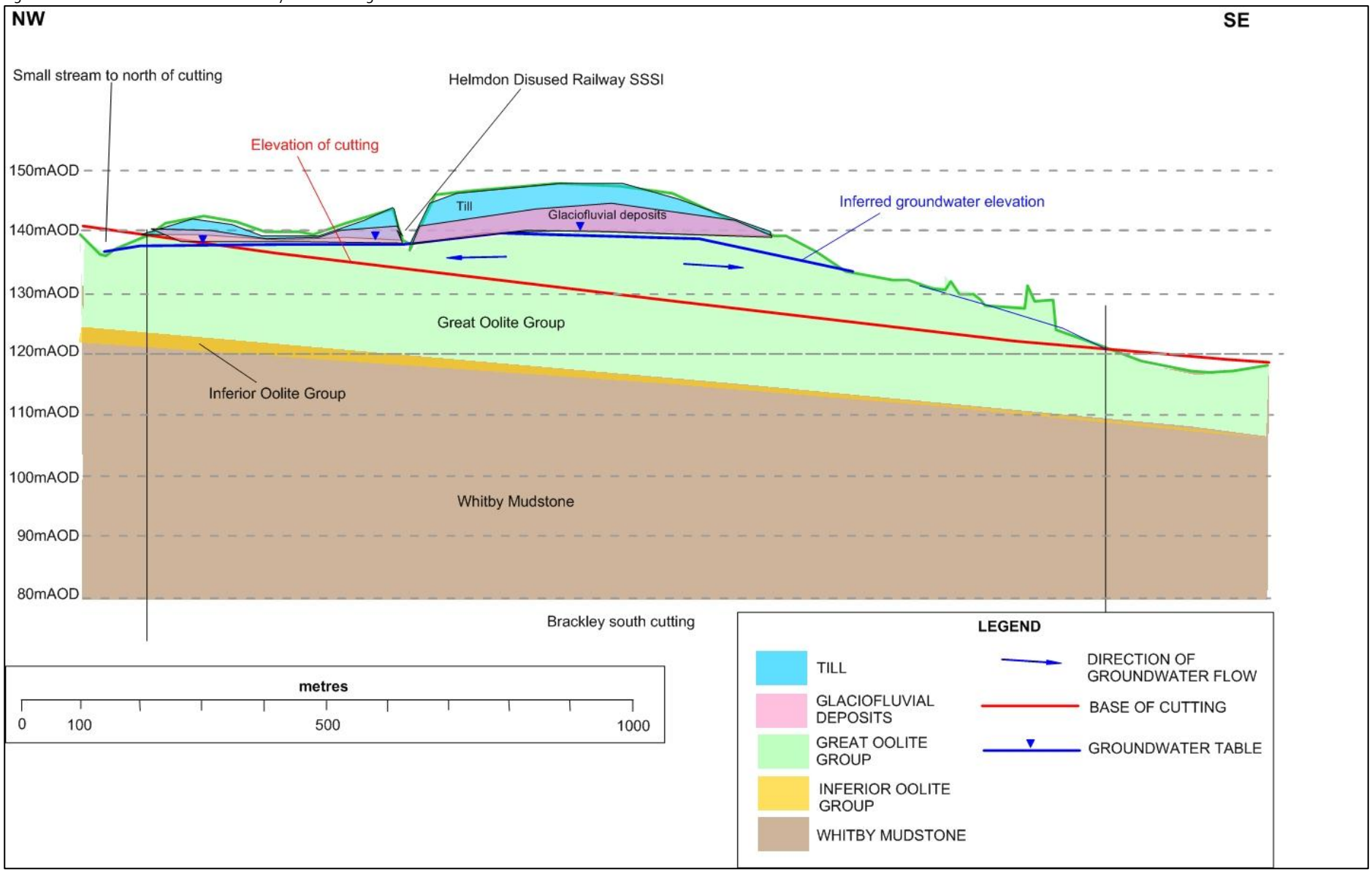
existing groundwater elevation and cutting elevation towards the southern end of the cutting.

5.2.30 The topography indicates that there is likely to be a localised small groundwater divide between Hall Farm and Fox Covert, with groundwater flow to the south of the divide towards the River Great Ouse in the south and flow northwards to the watercourse flowing through Coldharbour Farm. Figure 10 shows the geology through the cutting and the inferred groundwater elevation relative to the cutting elevation.

5.2.31 The Helmdon Disused Railway SSSI cutting cuts through the Glacial Till and Glaciofluvial deposits into the Great Oolite. The proposed cutting will be approximately 3.6m below the existing railway SSSI.

5.2.32 The Helmdon Disused Railway SSSI will be affected as groundwater beneath it will drain into the cutting. The connectivity between the base of the existing railway cutting and the water table will be disrupted. The water table will be lowered for a distance up to 490m from the cutting. The SSSI supports locally scarce plant species and invertebrates and is particularly important for butterflies including the small blue butterfly, a species of principal importance in England. Whilst there will be a loss of connectivity with groundwater, the species designated as important features of the SSSI are not considered to be dependent on groundwater. As such, the effect of dewatering at the cutting on the SSSI will be negligible and not significant.

Figure 10: Schematic section of the Brackley south cutting



5.2.33 With application of Sichardt's equation, the approximate zone of influence can be determined which provides an indication of how far from the route that the effect of dewatering will extend. The calculation considers a hydraulic conductivity of the Great Oolite Group as 0.00055m/s derived using information in the BGS, 1997[12]. The maximum depth of dewatering will be 10m, which results in a maximum extent of 490m from the cutting as demonstrated in Figure 11

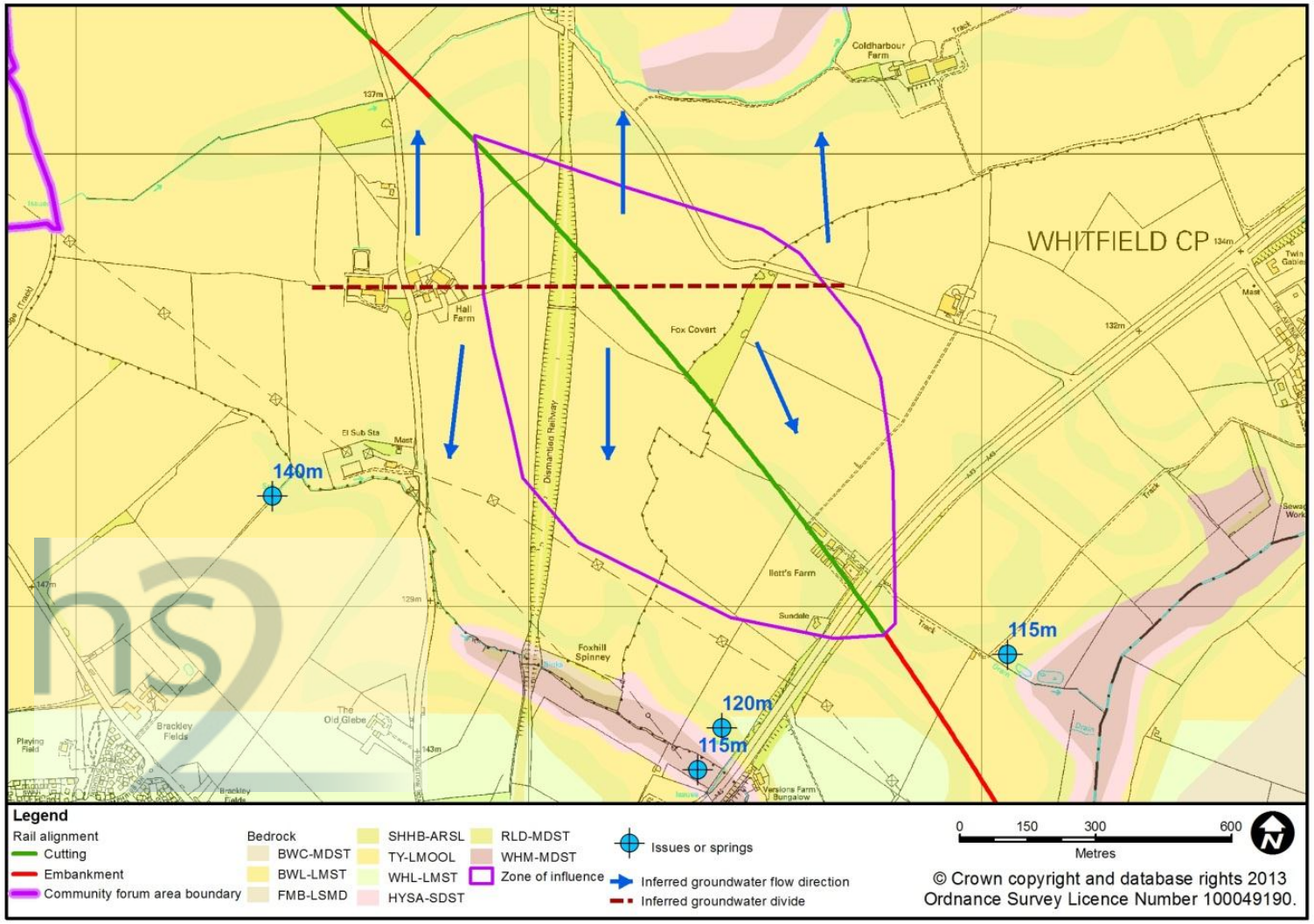
5.2.34 There is a small stream at the north of the cutting, close to Radstone. The stream is likely to be in connectivity with groundwater in the Great Oolite Group. However, any significant impact to groundwater flow and levels will not extend to the stream. There is sufficient thickness of aquifer below the cutting to ensure flows are not significantly disturbed (see Figure 11).

5.2.35 The spring at 140m elevation will not be significantly affected as a negligible volume of catchment to this spring will be impacted.

5.2.36 There is a spring/issue on Illets Farm at 115m elevation that will have a reduced catchment supplying it. It emerges, however, below the level of the base of the cutting and is likely to continue to flow. The impact is thus considered to be moderate, with a slight and not-significant effect.

5.2.37 The springs/issues at 115m and 120m elevation are immediately adjacent (and upstream) to the A43. They are located to the south of the cutting and will be affected by the reduction in flow within its catchment. There will be a reduction of approximately 60% in the catchment contributing to one of the springs where the thickness of aquifer will be reduced as a result of the cutting. The springs contribute to flow in the small stream flowing to the south-east, although the stream is also fed by the spring at elevation 140m that will not be affected by springs and issues further down-stream. As such the stream flow is unlikely to be significantly affected. The two issues are considered to be a low value receptor, there will be a moderate impact on these issues, with a slight adverse effect, which is not significant.

Figure 11: Approximate zone of influence for the Brackley south cutting[15]



[15] Key to geological units in legend: BWC-MDST = Blisworth Mudstone Formation, BWL-LMST = Bilsworth Limestone Formation, FMB-LSMD = Forest Marble Formation, SHHB-ARSL = Sharp's Hill Formation, TY-LMOOL = Taynton Limestone Formation, WHL-LMST = Whitby Limestone Formation, HYSA-SDST = Horsehay Sand Formation, RLD-MDST = Rutland Formation and WHM-MDST = Whitby Mudstone Formation.

Impact to groundwater quality from deposition of temporary earthworks stockpile material

5.2.38 There are five temporary stockpiles for earthworks material which are to the north-east of the route, east of Brackley.

5.2.39 The stockpiled area will not lie within a SPZ for a public water supply or within the zones of travel time relating to private groundwater abstractions.

5.2.40 Suitable quality criteria for the material placed in the temporary stockpile will be defined prior to material being placed. The draft CoCP (Section 15) defines the controls and guidance that will be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. The criteria will be determined to ensure that there is no significant degradation to groundwater quality as a result of the placement of material. The criteria will be agreed with the Environment Agency before placement of the material. The management of the material will be in accordance with the CL:AIRE Definition of Waste: Development Industry Code of Practice[16] (as stated in the CoCP).

5.2.41 The material deposited in the stockpile is considered to comprise natural material excavated for the cuttings in this study area and as such is unlikely to contain constituents that will adversely affect the groundwater quality. As such, it is considered as a generally clean, inert material. Notwithstanding this, the compliance criteria will provide a further level of security to protect groundwater qualityThe compliance criteria will take into account the amount of infiltration to the stockpile or percolation under the stockpile, site drainage design and the concentrations present in samples collected from the arising.

5.2.42 It is concluded that there will be a negligible impact on groundwater quality in the Great Oolite aquifers and Glaciofluvial deposits aquifer and a neutral effect from any stockpiles.

[16] Contaminated Land: Applications in Real Environments (2011) The Definition of Waste: Development Industry Code of Practice (Version 2, March 2011).

6 References

Arup/URS, (2012). *HS2 London to West Midlands Environmental Impact Assessment Scope and Methodology Report*.

Arup/URS, (2013). *HS2 London to West Midlands Environmental Impact Assessment Scope and Methodology Report Addendum.*

Arup/URS, (2013) *Phase One: Draft Code of Construction Practice. London*, HS2 Ltd.

Atkins, (1997). *Environment Agency Thames Region, South West Chilterns Model, Data collection and formulation of the conceptual model, Final report*.

British Geological Survey (BGS), (1997). *The aquifer properties of major aquifers in England and Wales. Technical Report WD/97/34,* Environment Agency R&D Publication 8.

CIRIA, (1986). *CIRIA C113: Control of groundwater for temporary works.* CIRIA, London, UK.

CIRIA, (2000). *CIRIA C515: Groundwater control – design and practice*. CIRIA, London, UK.

Contaminated Land: Applications in Real Environments, (2011) .*The Definition of Waste: Development Industry Code of Practice (Version 2, March 2011).*

Department for Transport, (2013). *Design Manual for Roads and Bridges:* http://www.dft.gov.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf

Environment Agency, (2009) *River Basin Management Plan, Anglian River Basin District.*

European Parliament and European Council (2000). Water Framework Directive - Directive 200/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.

Murname, E., Heap, A. and Swain, A., (2006). *CIRIA C648: Control of Water Pollution from Linear Construction Sites*. CIRIA, London, UK.